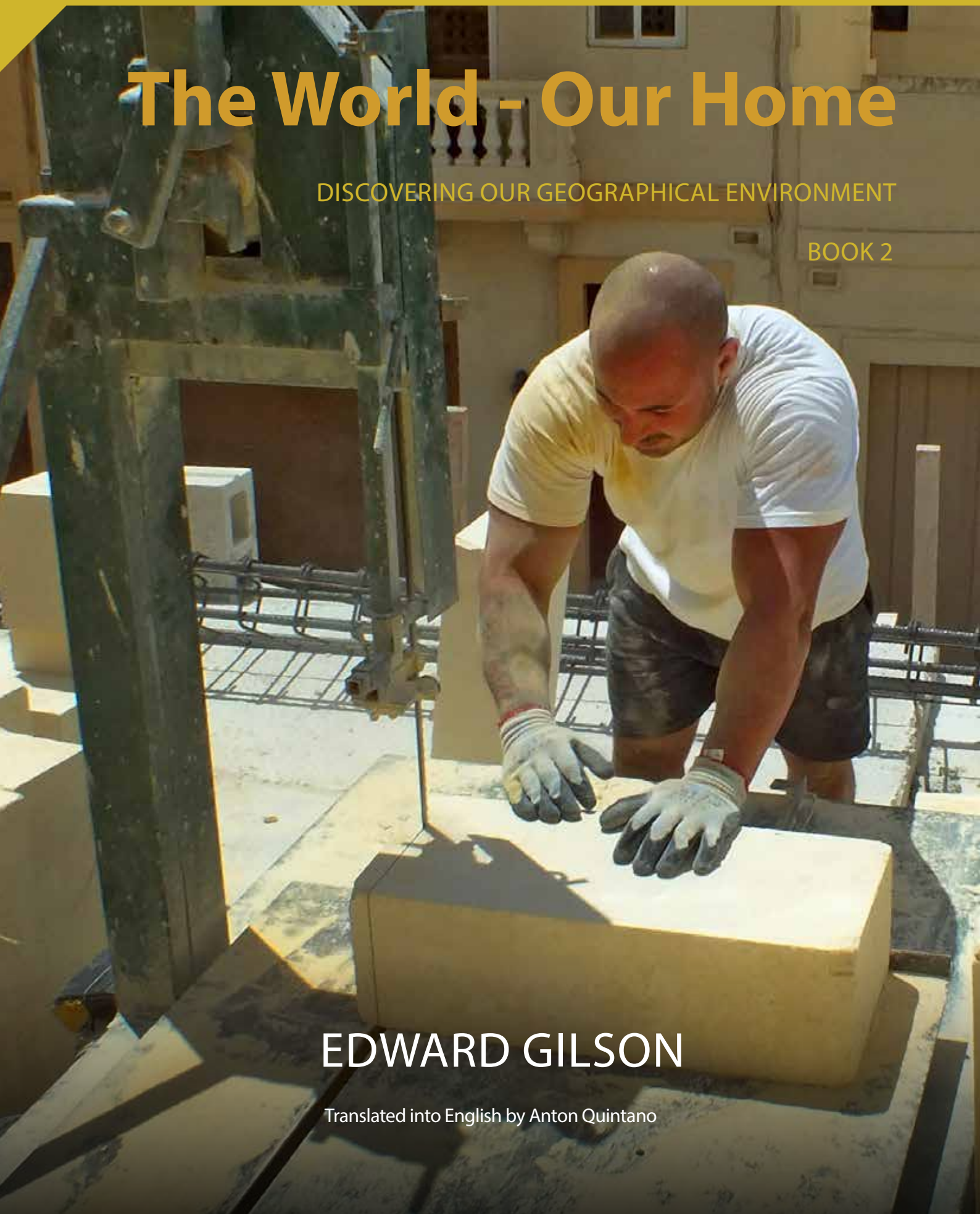
The World - Our Home

DISCOVERING OUR GEOGRAPHICAL ENVIRONMENT

BOOK 2



EDWARD GILSON

Translated into English by Anton Quintano

The World – Our Home 2

Discovering our geographical environment

A geography textbook for the fourth year of secondary schools

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More resources for the teaching of Geography

Geography has developed widely through the years and nowadays it is considered as a social science which studies the relationships between man and the environment. The physical environment, which took millions of years to form, is quite dynamic and several processes are at work to continue its evolution. In the past a perfect balance existed between the natural environment and all the living creatures. However, due to fast technological developments, humans are today seriously threatening the harmonious relationship which existed. In the news one may hear of the damage being done: the pollution of the aquifers caused by farming practices; the pollution of seawater by toxic chemicals; the increase in waste and landfills; overfishing and the reduction of tuna fish; the overuse of pesticides which is polluting water; the loss of soil due to malpractices by farmers; global warming as a result of the increase in certain gases in the atmosphere; the exploitation of natural resources; the destruction of coastal areas due to tourist development.

This is the second book in a series of three by which the students will be able to understand not only the physical processes which formed the Maltese Islands but also the actions of man which are quickly changing his own environment. These books provide the students with the knowledge, skills and values that are necessary for them to become good citizens who live sustainably and responsibly towards our and future generations.

These books are replete with colourful and attractive illustrations which motivate the students in their interest. Moreover, they contain many stimulating exercises about various environmental themes. The students are hereby encouraged to research, analyse and apply their knowledge especially with a view to solving environmental problems and taking decisions that lead to an agreeable environment.

All teachers are advised to use the resources available in these books while minding the different abilities of their students in order to adapt for their needs. The photos, illustrations and exercises facilitate learning while making both the subject and its learning more interesting for the students. The point of departure must always be the student. Therefore the books should not be covered faithfully from cover to cover but according to the needs of the students. In fact these books are meant to be an aid for the teacher, same as the resources found in the Geography room of Fronter such as the worksheets, photos, maps, films and illustrations that are used by means of the interactive whiteboard. These books provide a pedagogical tool for the teacher since they cater for students of very different abilities.

I thank all those who gave their input in this publication, most especially the Heads of Department of Geography and the National Council of the Maltese Language.

Edward Gilson
Education Officer (Geography)

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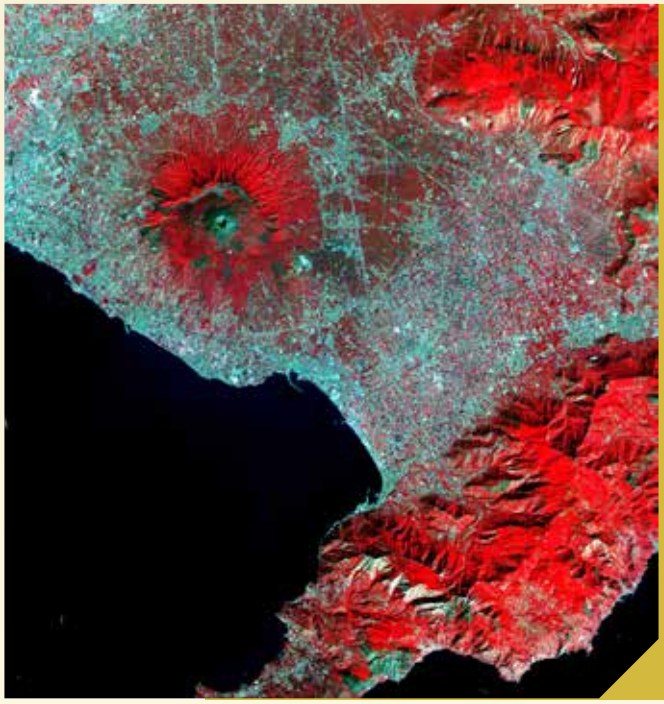


The increase in energy production and consumption is putting much pressure on the environment, so much so that nowadays we are trying to protect the few remaining natural resources. This can be achieved through sustainable development by which the standard of living is improved and the environment is protected at the same time. This can be done by decreasing and recycling waste, reducing the use and waste of energy at home, by using renewable sources of energy such as wind, solar and biomass, as well as by reducing emissions from vehicles and power stations.

Sources of Energy

1

Energy is needed for a comfortable living. It provides ways to lighten, warm or cool our homes as well as to cook meals. Energy is also required for commercial and industrial development and most importantly, for transportation.

Fortunately the natural environment provides us with a large variety of energy sources. Gas, coal and petroleum (oil), that is the fossil fuels, as well as wood, uranium, rivers, wind and the sun can all be used for the generation of electricity. Energy sources such as fossil fuels are also said to be non-renewable since there is no way to find more of such fuels once they are depleted. Other new sources such as the sun or wind are limitless, therefore renewable and so can be used with greater efficiency. More importantly they are sustainable and have little impact on the environment.

At Amersfoort in the Netherlands all the energy needs of the inhabitants are provided by photovoltaic panels placed on the rooftops of buildings. All the electricity generated in this town comes from natural sources and does not harm the environment.

Fossil Fuels

In today's world energy is mostly derived from three main sources: petroleum (oil), natural gas and coal. All these energy sources come from the remains of plants and creatures which lived hundreds of millions of years ago. Oil and gas were formed more than 300 million years ago from microscopic organisms which lived in seawater. On the other hand the remains of trees and plants which lived on land brought about the formation of many layers of coal.

These sources of energy are non-renewable since their reserves are being used much faster than they are being formed. According to estimates by geologists there are coal reserves for another 300 years at the current rate of use. On the other hand oil and gas reserves are much smaller. In fact at the current rate of extraction, oil will only serve us for another 50 years, and gas for 60 years. At present, about 75% of global energy comes from the burning of these fossil fuels. These cause the emission of large quantities of smoke with greenhouse gases and other substances which pollute the air and cause climate change and acid rain. The toxic smoke emitted from the chimneys of power stations damages natural ecosystems and is harmful to our health.

Work in coal mines is very dangerous. Occasionally workers were killed when the mine collapsed or due to an explosion. On the other hand when coal stored at the surface leaves a serious environmental and visual impact, as shown in the photo below.

Coal was the motor behind the industrial revolution. For the first time work was being done by machines, powered by steam which was produced by water being boiled by burning coal in industrial areas located near to the same coalmines. Coal remained the main source of energy for many years and the world developed through its use. The demand for coal was large and millions of miners worked in deep mines under bad conditions in order to find, excavate and extract coal. Nowadays coal production has decreased since both production costs and risks at work are high. Over the years, many countries stopped the importation of coal and have changed over their power stations to oil and natural gas which are cleaner and less dangerous. Electrical generation by means of coal fired power stations causes air pollution by means of carbon dioxide CO_2, (which leads to climate change), and sulphur dioxide SO_2, (which is the main agent of acid rain). Coal is heavy and bulky to transport and the ash which is left over must be dumped somewhere.

As a means of electrical generation, oil and gas are more efficient than coal. More importantly they are easier to transport from one place to another by means of pipes and large tankers.

Nowadays, many countries depend on oil and gas for their source of energy. Apart from being used in power stations, oil is also used in transport in the form of diesel, petrol and aviation fuel. It is also used in the production of various commodities such as plastic, medicine and fertiliser. Like coal, oil and gas pollute the air, but the CO_2 and SO_2 emissions are much less. Natural gas is the cleanest source of electricity generator from among the three fossil fuels.

During the whole process of oil production involving drilling, extraction and transportation, serious accidents may happen, which cause pollution of the air, land or sea. Sometimes large amounts of oil were spilled on land or sea while it was being transported from one country to another by huge pipes or tankers. Such accidents cause a deep and negative impact on the environment for a number of years. Moreover the price of oil and gas varies greatly in international markets since it is affected by the current economic, political and military conditions.

Many villages in Africa do not have electricity and they only depend on firewood in order to generate the energy needed to cook their meals or warm their homes. Firewood is also sought in the cities for the same reasons and therefore there is a growing market for this product. In cities that are far away from forests, the price of firewood is higher than that for food. Africans living in the cities must pay an increasing price for firewood as it becomes scarcer.

In poor African and Asian villages, only firewood is available for energy. Often children and women collect firewood which is used to cook meals and to warm their homes. The amount of trees near the villages is decreasing and therefore the way to fetch firewood is becoming increasingly longer. In certain African countries such as Ethiopia, firewood has become so rare that women have to travel ten kilometres and spend most of the day walking in order to fetch enough provision for a single day. The cutting of so many trees is conducive to deforestation, soil loss and desertification.

Nuclear Energy

In one way or another many countries will have to curtail their dependence on fossil fuels. Alternative sources of energy must be found since reserves of oil and gas are scarce and diminishing fast. Moreover the burning of fossil fuels leads to large emissions of toxic gases which damage global climate. For this reason, along the years, many countries have built nuclear power plants instead of the more traditional power stations fired by coal, oil or gas.

Nuclear power is created by the splitting up of uranium atom in nuclear reactors. By this process, called fission, a great energy is formed to heat water turning it into steam. This steam turns the turbine which then produces electricity. Uranium is a non-renewable metal. However since it can be found in large quantities, its reserves can serve us for many years to come. The re-use of nuclear waste is also possible. This keeps our mind at rest that the reserves of this metal will serve for a long time. After its extraction from underground, uranium is shaped into rods according to the specifications needed by the nuclear reactor. One rod can serve for six years thus reducing the costs of transporting this metal. While electricity is generated in a nuclear power station no toxic gases which can pollute the air are emitted.

No fuel is burnt in nuclear reactors. Therefore no carbon dioxide or other pollutant gases are emitted from such power plants as happens in traditional power stations.

Fukushima nuclear power station in Japan was built with high security controls. It was meant to withstand earthquakes and high tsunami waves which originate in the sea-bed. However, on 11 March 2011 these measures were rendered useless by the powerful earthquake which struck with a magnitude of 9 on the Richter scale and the subsequent tsunami. Although the building withstood the tremor, the 15-metre high waves flooded the cooling systems of the reactors which broke down. After some explosions, it was feared for some time that the nuclear power station might explode totally and a radioactive cloud be emitted, as had happened at Chernobyl 25 years previously. For months many workers risked their life in order to control the reactor and block any radioactive substances from spreading into the air, sea or soil. Fortunately no one died in this accident, however, about 100,000 persons lost all their belongings when they had to evacuate their homes which were too close to the power station.

However, many people are aware of dangers to health which these power stations pose especially after what happened at Chernobyl in the Ukraine in 1986. After an explosion in one of the nuclear reactors and the consequent emission of radioactive gas many people in

Eastern Europe became ill. One other problem is the disposal of used uranium rods. These are very dangerous since they remain radioactive for thousands of years. In many countries these are being stored above ground under strict surveillance, however, in other countries this radioactive material is being buried in concrete blocks and stored in deep bunkers underground.

On 26 April 1986 the worst nuclear disaster in history happened when the reactor at Chernobyl power station in the Ukraine (which at that time formed part of the Soviet Union) exploded and took fire. A radioactive cloud soon spread towards Russia and Europe. Large parts of the Ukraine, Belarus and Russia were contaminated with very high levels of radiation resulting in the rapid evacuation of about 336,000 people. More than 600,000 people suffered inflammation and other illnesses caused by the high radiation levels. More than 4,000 people died of cancer and till now, many are still suffering. This accident also affected distant places. Radioactive rain contaminated the land and many farmers suffered the loss of their produce. Fifteen months later in Scotland for example, 560 farms were found to be still contaminated and the farmers could not sell their cows or their milk due to traces of high levels of radiation in their products.

As soon as the nuclear power station of Chernobyl in the Ukraine exploded, the inhabitants of Pripyat had to leave all their belongings behind and evacuate the town. They could take nothing with them since all things were contaminated. Nowadays this zone is still abandoned with a large number of uninhabited apartments since radiation levels are still high. According to scientists life near Pripyat can only come back to normal in about 200 years' time. However, in the immediate environs of the reactor, 20,000 years have to pass for any risk of radiation to subside.

Many security measures are now being taken in nuclear power stations in order to avert accidents as happened in the past. This is why the capital expenditure for the construction of a nuclear power station is very large, much higher than that for a traditional oil- or gas-fired one. Nuclear reactors are covered with a concrete structure so that radioactivity will not escape. Another headache is the risk posed by the radioactive waste that will still be in place once the reactor is decommissioned. This radioactive material will still be generating heat and radiation for years to come. In Sweden as in other countries this uranium waste is stored underground in a large concrete cover.

Opinions differ regarding the building of new nuclear power stations. Many think that they are too dangerous even when all the latest precautions are taken. Environmental groups such as Greenpeace think that nuclear accidents can still occur due to various factors, such as human errors, breakdown in the machinery, natural disasters or terrorist attacks. On the other hand some believe that it is the only source of energy which can sufficiently replace the fossil fuels. As of 2017, 30 countries worldwide were operating 449 nuclear reactors to generate electricity. These are mostly found in the United States of America, France, Russia and Japan. In Europe, France produces 75% of its electricity supply by means of 60 nuclear power stations spread out throughout its territory. In 2008 after an increase in the price of oil and the push toward reducing CO_2 emissions, many countries were considering the construction of new nuclear power stations. However, after the Fukushima accident, many of these have had second thoughts, such as neighbouring Italy.

Solar and Wind Energy

Energy from fossil fuels in non-renewable. There will come a time when coal, oil and gas reserves will be very scarce or even run out. Therefore we need to turn to renewable sources of energy which will never be depleted. Among such sources one may mention water (hydro-electric power and energy from waves and tides), wind, sun, geothermal energy and biomass. These are clean alternative sources and their environmental impact is minimal. The amount of energy being generated by these sources is small, its global share being about 15%, however, their use is increasing slowly. It is estimated that the amount of energy which the Earth receives from the sun is 7,000 times greater than the present day global energy requirement. Till now people are not exploiting this source and are only using a small amount. Solar energy is being used for water-heaters avoiding the use of electricity.

Solar energy is becoming increasingly popular even in distant villages of Africa and Asia. In such places where there is no central electricity supply, the sale of photovoltaic panels is increasing.

Here one may see the Moura solar panels plant in Portugal, which is one of the largest electricity plants, situated in a very sunny place. 190,000 photovoltaic panels, producing 88GWh electricity annually, were installed on an area as large as 130 football fields.

A number of photovoltaic panels are being installed on rooftops so that solar energy be turned into electricity. Solar energy is renewable, safe, clean and efficient. Since this energy depends on sunlight there are problems when days are overcast and during the night. Another problem lies in the fact that they need a large area in order to produce substantial amounts of electricity.

Many countries are experimental on other forms of solar panels which would need less ground for a greater generation of electricity. In the photo above one may see the solar furnace of Odiello in the French Pyrenees. This structure uses less space than photovoltaic panels by concentrating the reflection of a number of mirrors on to a small area thus creating a great amount of continuous heat. At the focal point the temperature may reach 3,000°C and this heat is used to produce electricity.

In other countries wind is also being used for power electricity production. This is possible by the installation of turbines on land or at sea. Wind energy is renewable, efficient and above all does not pollute the air. Moreover new turbines need a smaller area and the land may still be used for other purposes. These turbines must be built in regularly wind-swept areas. Electricity from these turbines may not always be available since wind usually blows intermittently.

Unfortunately groups of 50-metre high rotors can have a large impact on the coast and the countryside. Some people say that birds can be hit by the large rotors of these turbines. They also need to be built at a distance from towns and villages since they produce some noise.

At present the largest wind farm in the world with 175 large turbines is near River Thames in England. These turbines produce the amount of electricity needed for more than 500,000 homes. Since this energy is clean, the United Kingdom has drastically reduced atmospheric pollution by saving on 925,000 tons of CO_2 annually.

Wind turbines can be mounted on land as well on reefs at sea. Turbines that are put up at sea give the advantage of saving the land for other uses and noise will be less audible. However, turbines at sea need specific conditions in their location and also more expense on maintenance.

Wind energy is produced by means of a large two-or three-armed rotor attached to a shaft. The propeller turns with the wind, which in turn turns the turbine thus producing electricity. The turbine is placed on a 100 metres high mast, while the rotor has a diameter of 130 metres, with a capacity of 5 megawatts of electricity each year, which is the average need of 2,500 homes.

The energy obtainable from the wind is proportional to the size of the rotor, so that the larger the arms, the greater the efficacy of the turbine. High mast help the turbine catch more wind. In order to produce more electricity, the rotors turn into the direction of the wind. Large rotors turn more slowly than small ones, thus reducing noise and the danger for birds.

Water, Geothermal energy and Biomass

Apart from the sun and the wind there are other sources of energy which depend on natural resources found in the environment. These sources, such as water and geothermal energy are part of a flow of nature and therefore will never be depleted. There is great interest in the development of these clean sources of energy. There are many reasons for this, partly because fossil fuels are becoming scarcer and will sometime run out. The price of oil is not stable and above all the burning of oil contributes towards the formation of acid rain and climate change.

Hydro-electric power is renewable and clean. Such power stations are usually found in the mountains at a distance from inhabited areas. Apart from providing cheap energy, the dams serve for the storage of water and minimise the risk of flooding.

The construction of large dams for hydro-electric power generation causes the loss of large tracts of land through permanent flooding. In the photo above one can see the remnant of the steeple of the church at Potosí in Venezuela. The area where the church stood was flooded when a dam was built hundreds of kilometres away to store water for the production of electricity. Thousands of people had to leave their belongings behind and evacuate since their villages were flooded by the waters. Moreover the silt which used to disperse and fertilise the fields after each flood is now settling behind the dam with the result that the farmers need to spend much money for fertilisers. The electricity pylons which carry the electrical current to the towns and villages cause visual pollution. This is clearly seen in the photo below where it was necessary erect many pylons to carry electricity from the power station to the cities.

Hydro-electric power is a type of energy which is used in many mountainous countries where there is a regular supply of water and snow. This type of energy is the most commonly used of the alternative sources, amounting to 7% of the world production of energy. This energy is created by the force of running water and therefore hydro-electric power stations are mostly found where water quickly descends mountains such as in Norway or near waterfalls such as at Niagara in Canada. This type of energy is also produced where rivers have been dammed in a valley so that the waters are stalled. The water builds up behind the dam and slowly a large lake is formed behind it. The water is then let through pipes through the dam at great pressure which turn the turbines that generate electricity. This is what happens at Aswan in Egypt or at Itaipu on the frontiers of Brazil and Paraguay.

China is the largest producer of hydro-electric power. The largest plant is built on the Yangtze, shown in the photo above, known as the Three Gorges Dam. There are 26 large turbines inside it, each producing large quantities of electrical power. This power station alone produces as much electricity as 18 oil-fired power stations do and the country is saving two million litres of oil every hour.

Twenty-four countries use geothermal energy producing 0.3% of world energy. In the photo below one can see the geothermal power station at Puhagan in the Philippines. Twenty percent of all the electricity produced in this country comes from geothermal plants. Similar power stations are spread throughout the country.

Geothermal energy is another source of energy which is however limited to a few countries. The earth's heat is used and therefore this energy is produced mainly in volcanic countries such as Iceland, Japan, New Zealand and parts of the United States. By this process water is thrown down boreholes in the rock which returns back to ground level in the form of steam since it would have met the heated rock underground. Then this steam is used to heat water in the homes or to turn electricity turbines.

This is a renewable and clean source of energy. However, the high temperatures and the volcanic activity in the environs create problems of maintenance. Often geothermal gases are emitted such as hydrogen sulphate which leaves a bad smell all around the plant.

In the photo below one can see a way of producing energy from tides. This particular turbine was placed in Northern Ireland and if it proves to be successful, many others will be placed in the northern seas such as in Scotland where 3 million tons of water are displaced every second by the tide. In the turbine shown below, the rotor is placed just below the surface. The water moves about the rotor at 14 kilometres per hour, turning it and thus producing enough electricity for 1000 homes.

The letting of water down the deep boreholes can cause tremors and there were cases when the geothermal plants had to be shut because of an increase in such earthquakes.

The increase in oil prices has motivated some countries to develop new systems of energy production such as biomass. This type of energy is produced when animal dung and other organic substances taken from landfills decompose and emit methane gas. Biomass is also extracted from farm products such as maize, cassava and sugar cane. When these are fermented, ethanol spirit is extracted, which is a biofuel that is mixed with petrol and diesel to be used as normal fuel.

Energy is also produced by burning waste in an incinerator. The waste is burnt in a uniform way in a large oven until all the waste becomes ash. The heat in the oven is used to produce electricity.

Fossil Fuels and the Environment

Presently most of the energy used comes from the burning of fossil fuels such as coal, oil and gas. These sources put pressure on the environment, not only during their end use but also during their extraction, processing and transportation. This pressure includes gases which pollute the air, land-use, waste generation and oil spills in case of accident. After all, these also contribute towards climate change, acid rain, loss of biodiversity and harm to our own health.

Most power stations are thermal plants where electricity is generated by turbines that are turned by steam produced from boilers heated by the burning of fossil fuels. In order for water to turn to steam large amounts of coal, oil or gas are needed. The steam moves the turbine which in turn operates the generator that produces electricity. Unfortunately such methods of electricity generation are very harmful to the environment. The same applies to the electricity pylons which carry electricity to the homes. Furthermore, the building of large tanks for the storage of oil and gas are an eyesore. The boiling water which is used in thermal power stations is thrown into rivers or in Malta's case, into the sea. This water is usually about 7° C warmer than the sea and has large amounts of chlorine added to it. Because of this algae and other marine plants die and other sea creatures suffer too.

When fossil fuels are burnt to boil water, dangerous gases are emitted from the high chimneys of the power stations and these gases are dispersed in the atmosphere causing much harm to the environment and to our health.

Carbon Dioxide (CO_2) is one of these gases and it is responsible for the greenhouse effect which causes climate change. Studies show that the average global sea and air temperatures are increasing, the ice-caps of the Poles and mountain-tops are melting and the level of the sea is slowly rising. The problem will become worse the more oils we burn. Sulphur Dioxide (SO_2) is another gas emitted by power stations. When mixed with rain it becomes sulphuric acid which may kill trees in the forests. If this acid rain falls in rivers and lakes it can also kill the creatures which live in water. The health of children and old people is adversely affected by these gases and other pollutants especially increasing cases of asthma and bacteriological infections. Moreover buildings constructed with lower globigerina limestone are also damaged. This type of stone is easily weathered, vermiculated and eroded as a direct effect of acid rain.

While fossil fuels are burned in thermal power stations, toxic gases are created and emitted from the high chimneys. These gases affect both global climate and people's health. Moreover such plants need a large area for their function and their high chimneys ruin the natural beauty of the landscape. This also applies to the high pylons, necessary for keeping the power lines high and for leading electricity through long distances.

As can be seen in the picture below, digging for coal in open pit fashion leaves large scars in the landscape. Great damage is done when coal is burnt in power stations by the gases which are emitted from the chimneys. Among these gases is sulphur dioxide which produces acid rain that kills forest trees and fish in rivers, as well as carbon dioxide which causes climate change. When burnt, coal turns into ash. This is dumped into landfills thus generating more waste and land pollution.

It may be said that each stage of the exploitation of oil leaves a negative impact on the environment. Large tracts of land must be cleared at the place of extraction, in the localities where the pipes are laid and also for the construction of the refineries where petroleum is refined into many different products such as petrol, diesel and tar. All these operations ruin the natural environment, cause visual and noise pollution, but most of all generate toxic gases especially when oil is being refined for use by power stations. The transportation of oil at sea can also have grave consequences, such as when large oil tankers run aground for one reason or another. Among such disasters one may mention the shipwreck of Exxon Valdez in 1989 in Alaska, that of Erika in 1999 on the French Atlantic coast, and the Prestige in 2002. Similarly in 2010, an oil rig exploded in the Gulf of Mexico causing an oil spill lasting four months.

These disasters leave a negative impact not only on the local industries like fishing and tourism, but also on the ecology of the place. The coast will be covered in oil as also thousands of poor creatures that die. This is what happened when the Exxon Valdez was shipwrecked on a reef in Alaska, spilling 36 million litres of oil into the sea. The oil slick was 2,600 km^2 in area and it killed 3,500 birds and 3,000 five-bearded rocklings.

Alternative Sources of Energy for Malta

Malta depends on imported fossil fuels for electrical generation. In order to produce electricity Malta imports and burns large quantities of oil and gas (coal was curtailed in 1995). This costs Malta much money and harms the environment. Malta is bound by agreement within the European Union that by 2020, 10% of its electricity be generated through alternative renewable sources.

Not all the renewable sources of energy mentioned previously are adapted to Malta. For example Malta cannot produce energy from tides since these are negligible. Furthermore rainfall is scarce and we do not have rivers that flow throughout the year. So hydro-electric power is not an option. The same applies to geothermal energy.

However Malta can build a number of wind turbines on land or on reefs at sea which would be able to produce substantial amounts of renewable energy. However, recent studies suggest that only about 5% of Malta's territory is suitable for such wind farms. This is because they must be placed at a distance from inhabited areas, in areas that are exposed to the wind.

Wind turbines can be built at sea where wind force is usually higher and the environmental impact is limited. Naturally the building and maintenance costs of wind farms at sea are much higher than for those placed on land.

Neither is Malta fully exploiting its great potential for solar energy, since it is only tapping a small percentage of this infinite source. Malta can save on 15% of the total expense on energy if photovoltaic panels are set up on rooftops of houses, hotels, schools, factories, hospitals and other buildings. This is another way of reducing the dependence on oil and gas. One may also mention the utility of solar water heaters which, though not generating electricity, help in saving on its consumption. Like wind, solar energy is clean, infinite and efficient, especially in Malta where the sun shines all year round.

The largest site in the Maltese Islands where a wind farm can be built at sea is Is-Sikka l-Bajda, off the coast of Marfa Ridge. On this reef 18 to 20 wind turbines can be located which would generate enough electricity for 21,000 households, equivalent to 80% of Gozo's needs. With such a project Malta could reduce about 80,000 tons of CO_2 emissions every year. It is certain that such a project would impact the environment. The rotors would be visible at a distance and would ruin the scenic beauty of the place. Moreover on the nearby cliffs there thrives Malta's largest community of shearwaters.

Delimara power station (shown on the right) started electricity production in 1992. The plan for this plant was to substitute the Marsa power station (picture below). Since demand for electricity supply continued to increase, Marsa power station was not closed even after Delimara power station was enlarged. The Marsa power station was closed down in 2017 when a new gas-fired power station was completed. Gas is the cleanest of the three fossil fuels. Cables have also been laid down between Sicily and Malta joining the Island to the European electricity network. By means of this cable, Malta is now able to buy electricity from other European countries. Malta needs an energy mix. Solar energy, wind energy and energy derived from waste are important for Malta so that the Island will not remain solely dependent on Delimara power station for its electricity supply.

Malta is also producing electricity from waste. For instance at Magħtab landfill boreholes have been dug to extract gases that have accumulated over the years of operation of the dump. The same is happening at Sant' Antnin waste recycling plant where the biogass thereby extracted provides electricity for as many as 1,400 households.

For many reasons Malta should waive its total dependence on fossil fuels in electricity production. It is a widely known fact that burning of oil and gas increases the incidence of respiratory conditions such as asthma. By the use of alternative sources of energy such as solar or wind we may have cleaner air and healthier people. Malta depends on the importation of oil and gas whose price is set by other countries. By the use of alternative sources of energy the cost of electricity production will decrease. The burning of fossil fuels in Malta's power station produces carbon dioxide (CO_2) which is a major cause of climate change.

At present the use of renewable sources of energy in Malta represents only 1% of the total electricity consumption. Government is issuing incentives to households and industry in order to invest in alternative sources of energy. Government is helping people to buy solar water heaters and photovoltaic panels to be set up on rooftops of private and public buildings. Public educational campaigns are also being conducted so that people save on consumption of electricity. For every household a number of energy-saving light bulbs have been distributed so that the electricity consumption for that purpose is only 20% that which would require traditional bulbs. There is also need for new buildings to be more energy efficient. For example windows can be double-glazed and roofs well insulated. Windows can be better positioned and large enough to provide better natural light.

1

a. What is a natural resource?

b. Give some examples of natural resources.

c. Why do you think that the global demand for natural resources is increasing at a fast rate?

d. What can be done so that we save on the remaining natural resources?

e. What is the difference between renewable and a non-renewable sources of energy?

f. What are fossil fuels?

g. Fill in the table on the right with the energy resources written below. (Some of the resources can be written in more than one column.)

non-renewable energy	fossil fuels	renewable energy

coal | nuclear energy | firewood | oil | tidal energy | wave energy | hydro-electric power | gas | wind | geothermal energy | sun

2

a. Why are coal, oil and gas called fossil fuels?

b. Match these sentences about non-renewable energy resources.

Oil formed millions of years ago

causes much environmental harm.

Fossil fuels are mostly used for

with the use of fossil fuels.

Fossil fuel reserves

are decreasing at a fast rate.

Many countries today generate electricity

from microscopic marine organisms.

The burning of fossil fuels

electrical production and for transport.


A


B

c. Study carefully pictures A and B then answer the following questions.

i. What natural resource is being extracted in picture A?

ii. Why do you think many countries are no longer using this resource to produce electricity?

iii. What environmental harm can be done during the extraction and burning of this resource for electricity production?

iv. The resource shown in picture A was the major source of energy during the Industrial Revolution. In brief explain what happened during the Industrial Revolution.

v. What natural resource is being extracted in picture B?

vi. What is this resource used for?

vii. Why do you think many countries prefer to use this resource rather than the one in A?

3

Complete the table on the right with information about crude oil.

a. In the first row write whether oil is a renewable or non-renewable resource.

b. In the second row briefly explain how oil was formed.

c. In the third row state how much reserves of oil are left globally at the current rate of extraction.

d. In the fourth row mention four large oil producing countries.

e. In the fifth row mention the uses of this natural resource.

f. In the sixth row mention some advantages this resource has over other sources of energy.

g. In the last row mention some problems and negative impacts which the extraction, transportation and use of oil may cause.

Information table on OIL	
Type	
Formation	
Reserves	
Major producers	
Use	
Advantages	
Disadvantages	

4

Nuclear power may be used as an alternative source of energy.

a. Write these sentences in the right column below.

There are large reserves of uranium

Uranium is cheaper than oil.

Many people are concerned about safety at nuclear power stations.

The capital expenditure for building a new nuclear power station is immense.

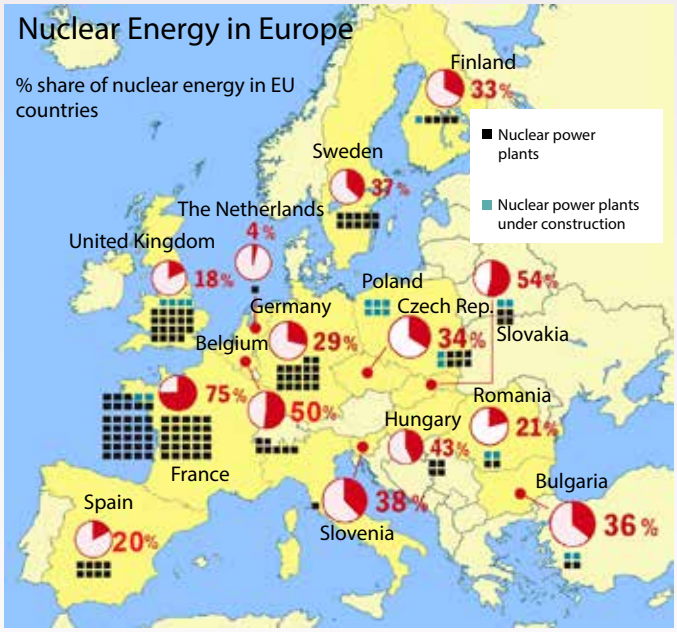
Nuclear waste remains radioactive for thousands of years.

No greenhouse gases are emitted from nuclear power plants.

Nuclear power plants do not produce acid rain.

Disposing of nuclear waste is difficult.

Nuclear Energy	
Advantages	Disadvantages



b. Look carefully at the map on the right.

i. With the help of the map, insert the missing information in the table.

Nuclear Energy in Europe		
Country	Reactures	Electricity (%)
France	58	
United kingdom		18
	17	29
Belgium		
		36

ii. With the help of the map fill in the blanks in the sentences below.

In Europe there are more than _____ nuclear reactor producing electricity. _____ is the country having most nuclear reactors, 58 in all, which produce about _____% of the electricity needs of the country. Two other European countries, Slovakia and _____ produce more than half their energy from by nuclear power stations. The United Kingdom too invested heavily in this type of alternative energy. In fact _____% of all energy generated is produced by nuclear power plants. Many countries have invested heavily in this type of technology due to the increase in the price of oil and the need to lower carbon dioxide emissions. In fact many countries such as Bulgaria, _____ and _____ are planning to construct new nuclear power plants. Other European countries such as Ireland, _____ and _____ never considered building such plants on their territory for fear of accidents such as that which happened at Chernobyl in the Ukraine in 1986.

c. Write a detail report for a local newspaper about a recent nuclear disaster. You can choose Chernobyl or Fukushima. In order to obtain maps, pictures and other information about the affected places, you can use the internet. You must explain the causes of the disaster, the harm brought on the inhabitants and the impact it had on the environment and the economy of the place.

5

Look carefully at the picture in page 30 showing an oil-fired power station.

a. Explain briefly how this power plant works in order to produce electricity.

b. Explain how such a power station may harm

- the air
- water
- people living nearby
- the landscape.

c. Study carefully the table which shows the amount of emissions from power stations which use different fossil fuels.

i. Which energy source is most harmful to our helath and to the environment? Why?

Emissions generated by the burning of fossil fuels (Pollution in kg/billion BTU of energy)			
	oil	coal	gas
carbon dioxide (CO_2)	75,000	100,000	53,500
nitrous oxide	200	250	50
sulphur dioxide	550	1,200	0.3
soot, ash and fine dust	40	1,350	3

ii. Which of the three is 'cleanest'?

iii. Do you think that the three fuels contribute towards the greenhouse effect? Why?

iv. Which two fuels are mostly responsible for acid rain?

v. How can this type of rain be harmful?

6

These reports describe two accidents that caused serious environmental damage.

Shipwreck of a large tanker

March 24, 1989

The Exxon Valdez shipwrecked while leaving the port of Valdez in Alaska. Millions of litres of crude oil spilled out at sea. A large number of seabirds, fish and five-bearded rocklings were covered in oil and died. Some whales and dolphins were also killed, however, most swam to other regions. Kilometres of coastline were covered in a thick slick of oil damaging the local industries and tourism.

a. What was the Exxon Valdez?
b. Where did the accident happen?
c. How did the accident affect sea creatures, the coast and the economy of the place?

A great explosion wrecks an oil rig

April 22, 2010

A large explosion completely destroyed the oil rig Deepwater Horizon which was drilling for oil from a deep well in the Gulf of Mexico. The explosion killed eleven persons and caused an oil spill into the ocean which lasted more than three months until the mouth of the well was blocked. It is estimated that about 7.5 million litres of crude oil were spilled into the sea. This is considered as one of the worst environmental disasters at sea.

d. What was the Deepwater Horizon?
e. Why did the incident occur?
f. Where was the Deepwater Horizon?
g. Research and write about the effects which this disaster had on the oil-rig workers, the inhabitants of nearby places, the environment and the economy of those places.

7

Look carefully at this wind turbine.

a. Draw the turbine as shown in the picture. Draw the mast and the three-armed rotor.

b. Draw a vertical line from the top to the bottom of the mast and mark the height of 50 metres.

c. By the same vertical line draw the normal height of a person.

d. Near the drawing write very briefly how these turbines generate electricity.

e. Write a few sentences about the impact which these turbines may have on the landscape. Do you think that these structures are elegant or are they ugly and an eyesore?

f. Read this article which featured in a Maltese newspaper.

Wind turbines at Is-Sikka l-Bajda

Tourist operators at Buġibba and Qawra are concerned about plans for the construction of twenty large turbines on is-Sikka l-Bajda, just off Selmun coast. They say these structures will be visible from their hotels. Instead of the nice views of St Paul's Islands, the tourists will be regaled with these enormous structures emerging from the sea. These will ruin the view and that is not their proper place. Birdlife is also concerned since the nearby cliffs are the nesting place of a large colony of shearwater, protected seabirds in Malta. However, the Resource Authority replied that Malta can no longer depend on the fossil fuels – hotel operators cannot see this, but many others do understand.

i. Why are tourist operators against this project which generates electricity without the need for fossil fuels?

ii. Who else might agree with the tourist operators?

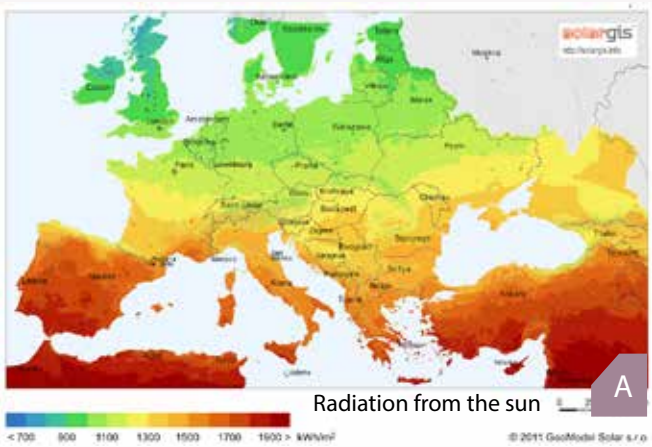
iii. Apart from the Resource Authority who else can favour such a project?

iv. Why do you think that the number of wind turbines has increased in many countries recently?

v. What is your personal opinion regarding these wind turbines? Must Malta invest in them or do you prefer other sources of energy? Why do you think so?

8

Study map A and table B.



A Radiation from the sun

Energy production by solar power Measure = thousands of tons of oil equivalent	
Cyprus	54
Denmark	11
Finland	1
Germany	580
Greece	160
Portugal	28
Romania	0
Turkey	420
Austria	108
Ireland	1
Switzerland	9
Italy	56
The Netherlands	23
Spain	137

B

a. Use the information given in table B to draw a bar graph. Show each country in a different colour.

b. According to map A which countries in northern or southern Europe have the greater potential for developing solar energy? Why is this so?

c. Which country makes most use of solar energy? Did you expect this? Why?

d. Mention three other countries which use large amounts of solar energy.

e. Mention two countries which at present make little use of solar energy but which possess great potential for it.

f. In Malta solar energy has developed at a fast rate and production from this source has increased greatly.

   i. Why do you think is Malta well adapted for solar energy generation?

   ii. Mention two ways by which solar energy is being tapped and used in Malta.

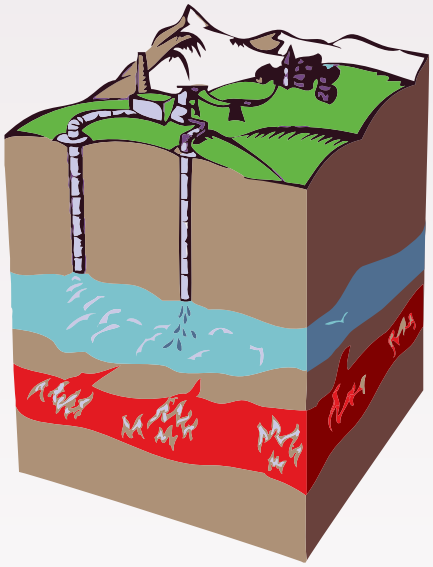
   iii. What are the advantages and disadvantages of having solar energy systems as used in Malta?

   iv. The Resource Authority believe that solar energy is a good choice for Malta. Draw a poster in order to encourage more people to use solar energy. The poster must clearly show the advantages of solar energy.

9

Study carefully the diagram below which shows the process by which geothermal energy is tapped.

a. Mark the diagram with the words written below.



deep borehole into which cold water at 10°C is poured

steam turns the turbines in a geothermal power station

the water heats when it meets hot rock

deep borehole through which the hot water emerges

electricity is carried to the homes

b. Where is this technology mostly used?

c. Make a list of advantages and disadvantages of geothermal power stations.

d. Mention three other alternative sources of energy which use water other than the fossil fuels.

e. Choose one energy resource which uses water and explain;

- the way in which energy is generated,
- where it is used,
- problems which it may cause,
- the advantages of this technology for the environment.

f. Explain the targets of the European Union regarding alternative energy sources.

g. What is being done in Malta for these aims to be reached?

h. What will Malta gain by reducing the use of fossil fuels and increasing alternative sources?

i. Mark (✔) the energy sources that are most suitable for Malta.

wave energy		wind energy	
energy from waste		geothermal energy	
hydro-electric power		solar energy	
tidal energy			

j. Explain why certain renewable sources of energy are not suitable for Malta.

10

Study carefully map A and table B.

A

a. Mention a European country which has coal deposits.

b. Mention a European country having gas-fields at sea.

c. Mention two African countries which do not produce fossil fuels.

d. Mention three countries that possess reserves of all three fossil fuels.

e. Which country is the largest consumer of electricity per person?

f. Mention two other countries from the list which are also large consumers of electricity.

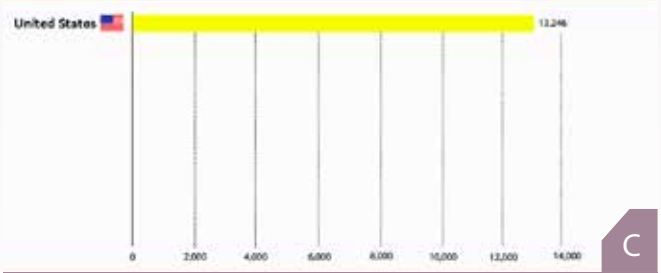
g. Mention two countries form the list that consume little amount of electricity per person. What does this imply about these countries?

h. Complete graph C using the information given in table B. Write the name of the country, the electricity consumption per person and draw the flag. Continue with the largest consumer countries first.

Average yearly energy consumption per person (2013) Yearly kilowatt-hour (kWh/annum)			
France	7,289	United Kingdom	5,516
China	3,298	Australia	8,356
Bangladesh	259	India	684
Kenya	155	United States	13,246
Mexico	2,092	Malta	4,685

B

Electricity consumption per person (2013)



C

Nowadays extreme weather such as strong storms and hurricanes are becoming more frequent. It is commonly thought this is due to greenhouse gases emissions. This is leading to global warming due to the emission of carbon dioxide (CO_2) originating from human activities in industry, power stations and transport.

Climate change

2

Some atmospheric gases help in keeping our world warm. These harness the sun's heat same as a greenhouse does. In fact this process is called greenhouse effect.

Due to the rapid economic and industrial development in the past 60 years, emissions of gases which trap the sun's heat energy have increased. World temperature is rising and warming because of these gas emissions from power stations, factories and vehicles. Scientists agree that people are causing this change in temperature and thus losing their control over the weather. In the news there are daily reports of disasters linked to climate change; the thawing of ice-caps, floods, drought, great storms, hurricanes and the extinction of many animal species.

We must do our utmost to reduce emissions that cause climate change. The governments of Malta as well as those of the other European Union countries have agreed to drastically reduce greenhouse gas emissions by 2020. These targets may be reached by investing in renewable sources of energy such as solar or wind power and by the greater use of smaller vehicles which use less fuel or public transport.

Greenhouse Effect

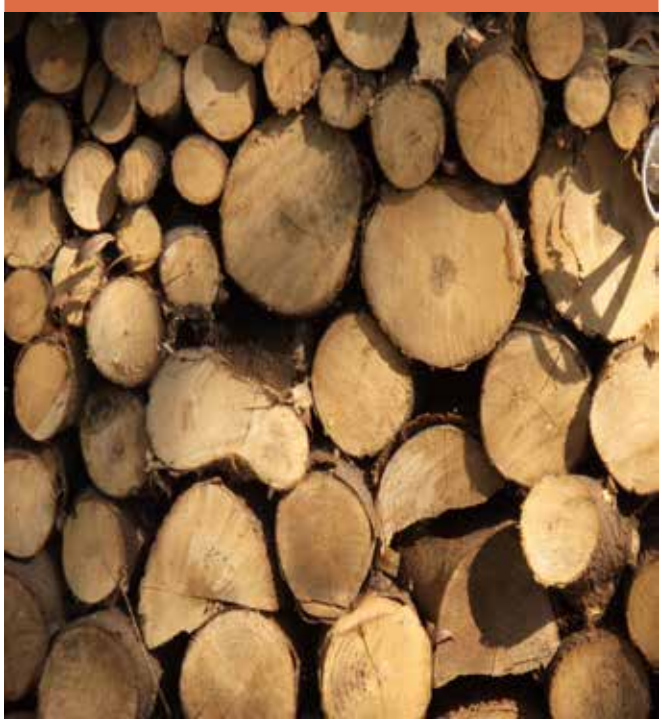
Greenhouse effect is a natural process by which the world keeps warm enough to be inhabitable. The different gas layers that cover the Earth keep a balance in the atmosphere which allows for life to thrive.

Gases such as carbon dioxide (CO_2) and methane allow the sun's rays to penetrate the atmosphere and therefore the land and sea are warmed. These same gases then trap and absorb part of the heat energy which the earth's surface reflects back to space. Without these gases the earth's atmosphere would have been much colder than it is that is -18°C, instead of the actual 15°C, and no one would be able to live in it.

Gases which trap the earth's heat in the atmosphere are called greenhouse gases. During the past two centuries, the demand for energy has increased due to the rise in population, industrial development and standard of living. Much energy is obtained by the burning of fossil fuels such as coal, oil and gas. In the last two hundred years the amount of carbon dioxide in the atmosphere has increased by 25%. This is the major contributor to the global warming and climate change.

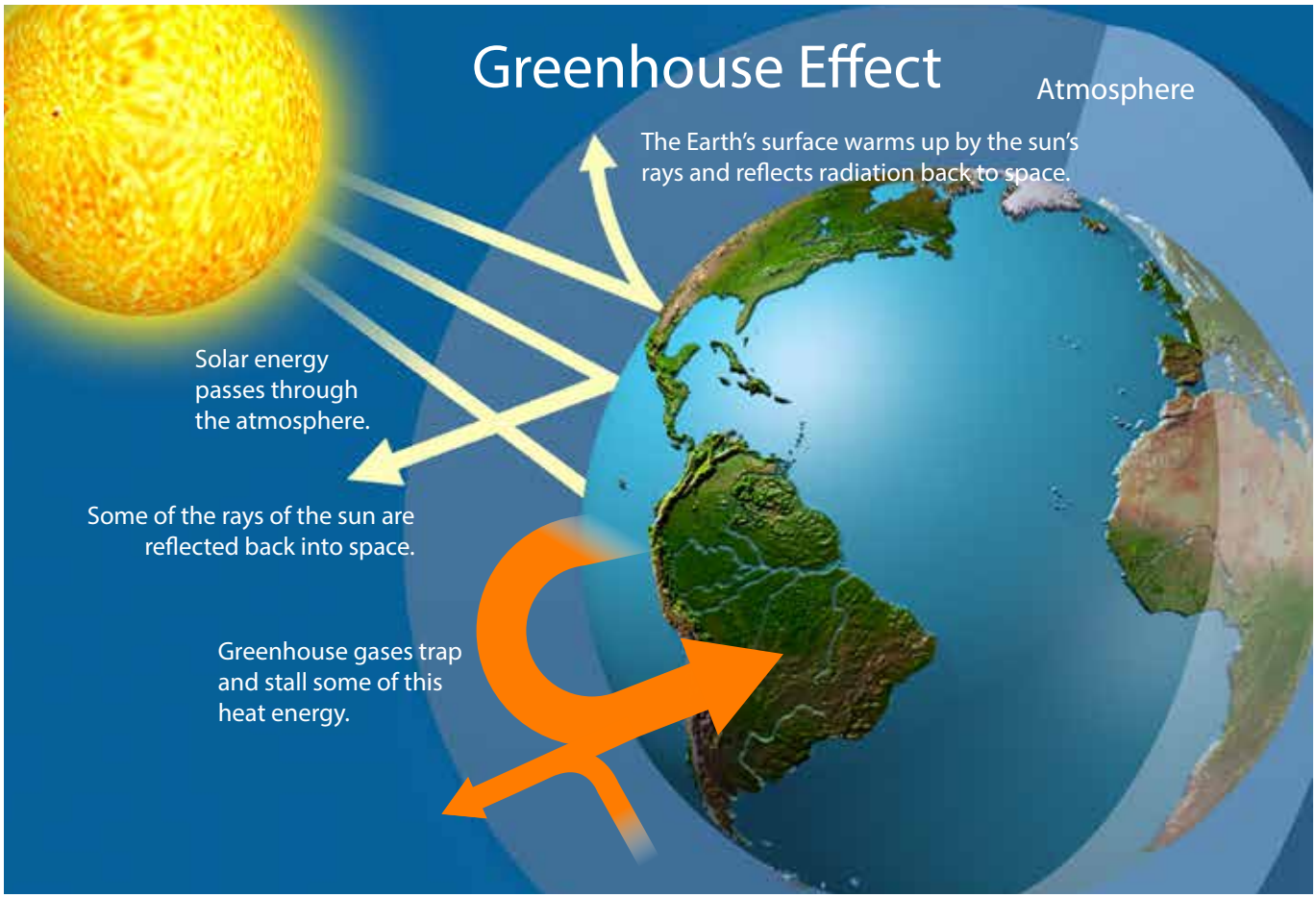
People are also producing large amounts of other gases which also adversely affect the natural balance of the greenhouse effect. One such gas is methane which forms during the decomposition of organic material in landfills as well as in the growing of rice and the production of natural manure.

The burning of fossil fuels such as coal, oil and gas produce large quantities of carbon dioxide in the air. Although they are necessary for power generation, in industry and in transport, they are responsible for climate change. For years people have aggravated the situation by cutting or burning large tracts of forest, especially tropical ones. Trees can help reduce greenhouse effect since they absorb carbon dioxide like a sponge and emit oxygen. It is therefore imperative that the rapid deforestation of the tropical forests be halted.



Chlorofluorocarbons (CFCs) are most harmful. This gas can be found in propellants, in refrigeration and air conditioning systems. Nitrous oxide is another greenhouse gas which increased greatly in the past 50 years. This is produced when fossil fuels are burnt in power stations, with the use of fertilisers in farming and in exhausts by vehicles.

Methane is another a greenhouse gas produced in part by man's activities. This is an invisible gas which rises from landfills as waste rots and decomposes. It is also emitted during farming processes such as the cultivation of rice and the production of natural manure.



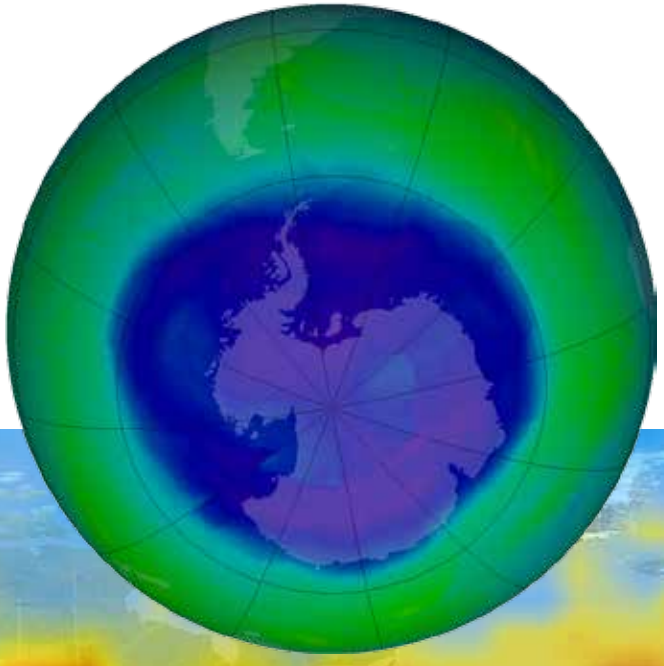
Due to the natural greenhouse effect the average temperature of the world's atmosphere is 15°C. Greenhouse gases make life possible. Had they not been present there would be nothing to stop the heat energy of the earth to be reflected into space and it would have been extremely cold. However, in a relatively short period of time people have destroyed the sensitive balance of natural greenhouse effect by greatly increasing the amount of gases such as methane, carbon dioxide, chlorofluorocarbons and nitrous oxide. These are now absorbing much heat which would otherwise have been lost into space and therefore world temperature is slowly rising.

Apart from being partly responsible for the increase in global temperature, chlorofluorocarbons (CFCs) which are used in industry are also seriously damaging the ozone layer. The fine ozone layer which is only about 3 millimetres thin is situated in the atmosphere at a height of between 20 and 30 kilometres.

This layer absorbs most of the ultraviolet rays of the sun which are very harmful to our health. This layer is being slowly depleted by the use of chlorofluorocarbons in industry, especially in the production of propellants, fridges and air conditioning systems. A thinner layer of ozone will lead to greater risk of illnesses and may cause skin cancer, damage to the eyesight or even total blindness.

The satellite photo by NASA (page 43 above), taken in September 2008, shows the hole in the ozone layer over Antarctica in blue. On that occasion the hole was spread out over 27 million square kilometre of the earth. This means that over those territories marked blue in the photo, the ozone layer was much thinner than the average. Fortunately few people inhabit those areas and therefore the danger to people's health is minimal. But there is still the danger that the hole may widen with countries like Australia, Chile, Argentina and New Zealand

being seriously affected. This is why the use of CFCs was prohibited in 1987 and the production of all these gases was stopped. For years to come, however, these destructive gases will still be present in the atmosphere and will continue to damage the ozone layer, although scientists believe the layer will recover its normal thickness within fifty years' time.



The world map below shows the regions with greater concentrations of carbon dioxide (CO_2) in red. Since 1922 CO_2 emissions increased by 38% mostly due to the burning of fossil fuels. In the last 20 years there has been a decrease in the use of fossil fuels in the more developed countries and an increase in the developing countries. For the first time China has surpassed the United States as the major producer of carbon dioxide emissions. India is not far less. In 1992 the USA were the largest producer of CO_2, followed by China, Japan and India. However, in 2002 India surpassed Japan and in 2006 China became the largest fossil fuel user and CO_2 producer.

Rise in the Earth's Temperature

Climate change is causing major concern in all countries of the world. This phenomenon regularly features in the broadcasting media and most people are conscious about its damaging effects on our planet. Global warming, accompanied by unusually extreme weather in different parts of the world, is attributed to the greenhouse gases emissions through man's activities, including industry, agriculture, transportation and energy production.

It is now certain that our world is warmer than it was thousands of years ago. In the past century the world's temperature increased by 0.6°C and the major rise happened in the past few years. 2016 was the warmest year on record.

Not all scientists agree that this is happening due to man's activities. Some say this is a natural cycle through which the earth passes periodically. Others are of the opinion that the world is approaching a new ice-age.

Notwithstanding this, most scientist estimate that until 2100 the average world temperature will be between 1.4° and 5.8°C higher than today. This increase in temperature will cause problems for people and their environment. We are already experiencing some of these problems with the growth of natural phenomena such as heat waves, high winds, hurricanes and exceptional drought. Such extreme weather is now affecting places which had never suffered the like before. Due to higher temperatures, tourist centres on the

The rivers of ice or glaciers of Argentina, Alaska, Himalaya Mountains and other regions are retreating every year. According to scientists by 2050 three quarters of the glaciers in the Swiss Alps will have melted completely. This is one clear proof showing that the threat of climate change is not only real but has also taken a quick course.

mountains have to close down since snow is fast thawing. Sea levels are rising due to the melting of the ice-caps in the Poles, and many inhabitants of low-lying coastal areas have to abandon all their possessions in order to settle on higher ground. Even if the sea level rises by only a few centimetres, cities like Bangkok, Dhaka, Mumbai and Alexandria will be vulnerable to permanent flooding.

Many plants and animals will be affected by the increase in temperature. Some will adapt to change, others will migrate to new habitats, while others still will become extinct since they will not be able to cope.

A recent study shows that the level of the sea is rising by 1 or 2 mm every year. This is due to two reasons. When the sea warms it expands, takes more space and therefore will rise. Moreover the warm temperatures are melting the huge ice-caps of the Poles and of mountains at a fast rate. This water finds itself into the oceans of which levels will rise. Therefore the level of the sea will rise covering vast low-lying areas. The peoples who live by the coast and near the deltas of large rivers such as the Nile in Egypt, the delta of the Red River in Vietnam and Brahmaputra in Bangladesh will find themselves flooded under water. The same will happen to Venice which was built on more than 100 islands in the North of the Adriatic Sea.

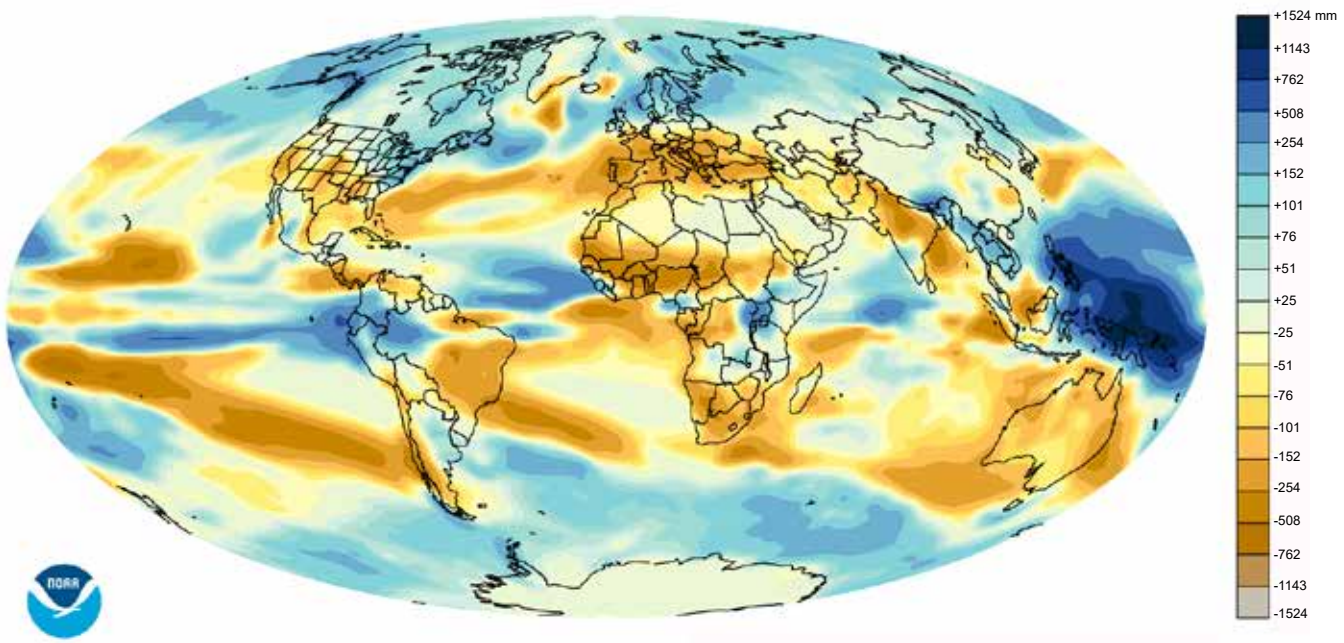
Many scientists believe that due to global warming large masses of ice in the Arctic Ocean will be melting every summer. Since 1979 the area covered by ice in September, that is the month in which ice is least present, has decreased by 8% every ten years. By 2085 only a small portion of sea north of Greenland will be covered in snow and therefore the Arctic Ocean will be completely ice-free during summer. New trade routes between Canada and Russia will be opened in summer and there will be greater economic gain. However, the problems will be much greater. Apart from flooding which will affect coastal towns, creatures which live on the ice-caps such as the polar bear will not be able to adapt to the new conditions and may become extinct.

The ice-cap in the Arctic Ocean

August, September and October

Scientists use computers in order to forecast climate change at the current rate of greenhouse gases emissions. The forecast says that there will be a complete change in the rates and distribution of rainfall on our planet. In many places, marked brown in the map, there will be a decrease in yearly rainfall. With such a decrease, agriculture produce in these places will be reduced and there is a risk of fertile land becoming a desert. There is also fear of diseases in new places due to drought. It seems that Africa will be most adversely affected by this phenomenon. In large regions of Africa great heat and drought are envisaged. With such worsening conditions, many more people will try to migrate to Europe.

Change in rainfall until the year 2100
(millimetres)



The Impact of Climate Change on Malta

Malta together with other Mediterranean countries will be greatly affected by climate change. This will bring serious problems to the economy, especially in agriculture and tourism. Malta will also face problems related to water availability, people's health and coastal erosion.

During the past 50 years Malta's climate has changed, becoming warmer and drier. The Maltese have witnessed a rise of 0.5°C in the average temperature and scientists forecast a rise of 3°C till the year 2100. Rainfall totals decreased during the past years and experts forecast a reduction of 17% in rainfall until 2100. With such new climatic conditions Malta is approaching the state of a semi-arid climate, similar to that of a hot desert.

Certainly less rain and higher temperatures will greatly affect agriculture and the natural environment. Warmer weather increases capillary action from soil, especially in summer, ths adding to drought.

The Maltese Islands may experience a scarcity of natural water resources and will have to depend even more on the desalination process leading to greater need for energy, which in turn will cause more greenhouse gases to be emitted into the atmosphere.

According to statistics issued by the Meteorological Office, the average sea temperature is also increasing. This phenomenon instils serious environmental problems since warm seas give origin to more energy in the atmosphere and consequently greater storms and stronger winds. Rain will be torrential, that is it will be heavier but in shorter period of time. A warmer sea also means that it will expand and its level will rise. Sea levels are also increasing due to the melting of the ice-caps in the Poles and on the mountains.

For its energy needs, Malta is still largely dependent on the burning of fossil fuels. Every year tons of CO_2 are emitted into the atmosphere. More than 60% of greenhouse gas emissions in Malta originate at the power station. Energy consumption in Malta has increased and this has caused greater emissions of greenhouse gases into the atmosphere.

A large proportion of greenhouse gas emissions also come from transport. There are more than 1000 motor vehicles per square kilometre in Malta and these produce a great amount of carbon dioxide and nitrous oxide emissions.

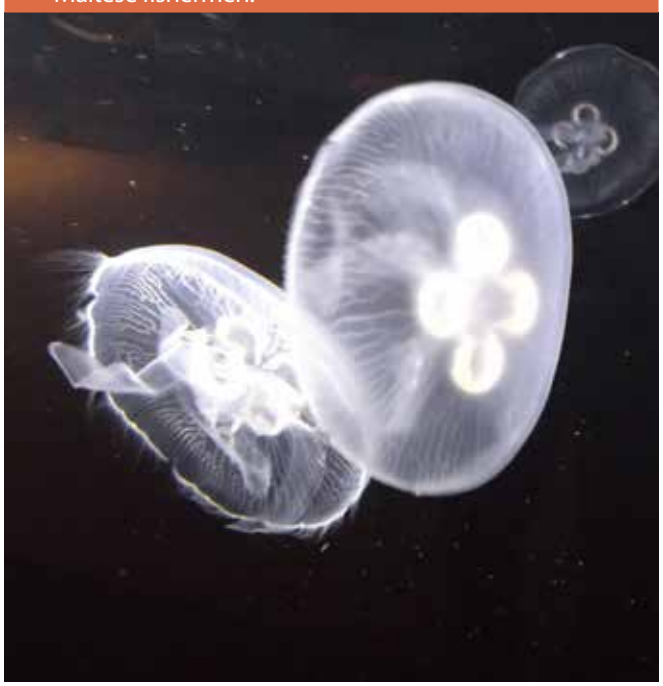
Sea level is forecast to rise 0.5 metres by 2050 and one metre by 2100. This may have serious consequences for Malta. Hundreds of people who live in low-lying areas such as Salini, Burmarrad, l-Imsida and tal-Pietà will have to move. Most sandy beaches will be submerged. This will greatly harm the tourist industry.

Sea level rise will also lead to further salinization of the mean sea level aquifer since more seawater will penetrate the rock from the coastal zones.

Countries further south will have bigger problems due to the heat forecast for the 50 years to come. People there will suffer famine following greater drought. A larger number of migrants from Africa to Europe is expected. This will also affect Malta.

Each year almost 2 million tourists visit Malta. Malta's economy largely depends on tourism. It is feared that if sea level rises at the forecasted rate many sandy beaches found in the Maltese Islands will be submerged by the sea. It is thought that within 50 years' time, the beaches at Għadira, Għajn Tuffieħa and Armier, all at Mellieħa, will disappear under seawater. Thus Malta will lose some of its best tourist attractions. The worse situation will be in those bays where a road has been laid out behind the beach such as Għadira and St George's Bays in Malta as well as Xlendi in Gozo. While the sea is slowly rising, the sand there will have nowhere to retreat and settle. Summer temperatures will continue to rise and tourists will prefer spending their holidays in cooler resorts. It is envisaged that resorts in the Central Mediterranean will no longer be as popular with tourists. This will harm these countries' economy.

The salinity of the Mediterranean Sea will rise due to high evaporation and less rain. Maritme ecosystems may change drastically due to this and also because of the warmer sea. Some species will suffer while other will be stronger. This will create a new ecological balance. Many believe that the jellyfish infestations of Malta's sea since 1981 is a direct result of the above conditions. Moreover warmer waters may lead to a change in the direction of sea currents which will cause migratory fish like tuna and swordfish to change their routes. This will harm Maltese fishermen.



Reports published by experts state that Malta is very vulnerable to climate change. It is thought that there will be an increase in the frequency and intensity of weather events such as storms, floods, drought and heatwaves. It is envisaged that Malta's temperature will rise and heatwaves will be stronger. Total rainfall averages will decrease and Malta will become drier. Rainfall will be torrential, causing flooding and will negatively impact farming and water supply. Fields will not have time to absorb the rain which falls suddenly, they will easily clog and rainwater will be wasted instead of filtering through to the aquifer. Water will become scarce.

Reducing Greenhouse Gas Emissions

One may say that all the world's countries agree that climate change is our planet's greatest problem. Man's irresponsibility, the needs of and increase in economic development as well as the commodities with which we are now used to, all entail substantial energy requirements. Climate change has taken a fast course and it will not be easy to halt it.

During the past years many meetings and conferences were held between the more developed and the developing countries so that this problem may be solved. World leaders have met at Kyoto in Japan, in Johannesburg, on the island of Bali, at Bangkok, at Rio de Janeiro, in Paris and in other European countries so that agreement may be reached for the reduction of greenhouse gas emissions. In one of these conferences, the member states of the European Union have agreed between them to cut down on CO_2 by 20% till the year 2020.

Climate change is everyone's concern, not just for governments. Everyone must do his utmost to reduce emissions coming from the burning of fossil fuels. This may be done by using less energy and by investing in alternative sources of energy which do not harm the world's ecosystem which has supported humanity since thousands of years ago.

Malta produces only a tiny fraction of greenhouse gases when compared to large countries. However, we still need to do our own part.

Malta is aiming at producing more energy from renewable sources, that is from the sun, wind and waste. It is planned that wind turbines be built both on land and at sea to cover the energy needs of 50,000 households. Some minor quantities of electricity have also been produced at the landfills and from Sant'Antnin waste recycling plant. By such measures Malta may reduce its dependence on fossil fuels and also its emissions of CO_2 into the atmosphere. Government is helping by granting subsidies to whoever buys energy-saving appliances or uses solar energy. Among these are solar water heaters and photovoltaic energy producing systems. By such renewable systems many families and companies are generating their own electricity and some are able to sell their extra produce.

We should be responsible too by cutting on waste of water and electricity using public transport rather than private cars, use energy-saving light bulbs or appliances and other measures to reduce our carbon footprint.

In many countries of the European Union, including Malta large vehicles which consume a greater amount of fuel and pollute more are taxed more than others which use clean technology and which produce less emissions. The aim of such measures, upholding the principle of 'polluter pays', is to encourage people to buy small cars with clean technology that pollutes much less. In Malta hybrid motor cars and buses are already in use which emit only little greenhouse gases. This is necessary since transport is the second largest polluter in Malta and Malta has the fourth highest car density in the world. In order to reduce the number of cars and CO_2 emissions from the roads we need to use public transport, bicycles and our own feet more.

Malta is sun-baked and this puts it at an advantage regarding the use of solar energy for water heating and for electricity generation. By the installation of photovoltaic panels on the rooftops of houses, schools, hospital, hotels, factories and other buildings, we would be saving on the use of fossil fuels and on the emission of tons of CO_2 in the atmosphere.

30% of all electricity generated in Malta is for domestic use. Saving on electricity in our homes will make a huge difference. This can be done if we switch off the lights and other appliances when not in use. Neither should we leave electrical appliances on stand-by and by day we should try to use only natural daylight. We should seek to buy appliances that are certified to be energy-saving and light bulbs which consume only a small fraction of other conventional bulbs. By taking these small measures which do not affect our way of life, we would be saving energy and resources. Moreover we would be reducing the emission of greenhouse gases.

1

Study carefully the diagram on the right which shows the natural greenhouse effect which helps sustain life on earth.

a. Join these broken sentences about the process of the natural greenhouse effect.

Our world is covered with a layer

the sun's light energy and heat pass through them.

These atmospheric gases allow

and the sea are warmed.

Due to this the land

the world temperature would be about 25°C colder and everything will freeze.

Atmospheric greenhouse gases absorb part

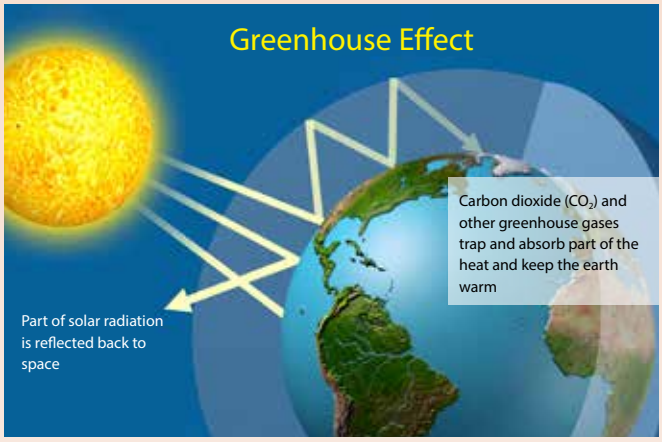
of the heat which the earth reflects back.

Some of the heat which is reflected by the earth

escapes back to space.

Without these greenhouse gases the atmosphere

of gases like carbon dioxide and methane.



b. Look carefully at graph A and graph B and answer the questions.

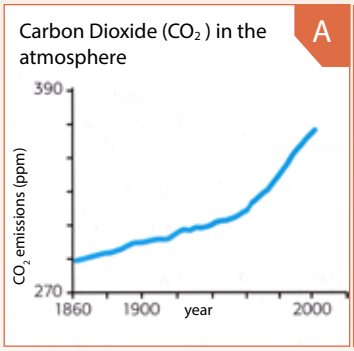
i. What was the increase in average global temperature between the years 1900 and 2000?

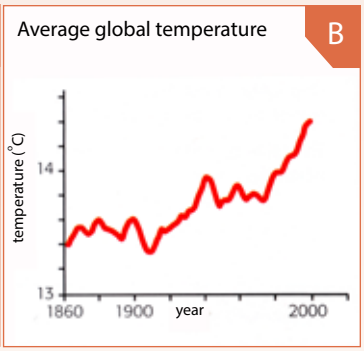
ii. Is the increase in carbon dioxide in the atmosphere constant or increasing at a faster rate?

iii. Explain why carbon dioxide is increasing so rapidly.

iv. Are graph A and graph B similar? What do you think?

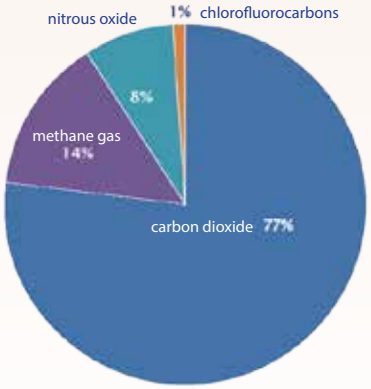
v. Thousands of years ago there was the contrary effect to that which we see today and that seen in graph B. What was this effect and where can it still be seen?





2

The pie chart shows the gases responsible for global climate change.



a. Answer the following questions.

i. Which is the major greenhouse gas responsible for global warming?

ii. Mention two other gases contributing to the greenhouse effect.

iii. Explain why these gases are called so.

b. Fill in the blanks in these sentences about greenhouse gases produced by human activities.

In the recent past greenhouse gases produced by human activities have increased greatly. The major greenhouse gas which is increasing global temperature is _____ dioxide. This is emitted into the atmosphere by power stations while burning fossil fuels which include _____, coal and gas. We cannot do without electricity. We need it for heating, _____ and lighting homes. Much oil is also burnt in transport, especially by cars, aeroplanes and _____. Forest trees are needed since they help us by _____ part of the extra CO_2 which we generate. Instead we are cutting trees at the rate of 100,000 square kilometres each year. The clearing and burning down of forests are responsible for 20% of the total global emissions of greenhouse gases, therefore all possible alternatives should be tried to stop _____. Another greenhouse gas produced by human activities is _____ which is an invisible gas emitted from _____, rice cultivation and from certain fertilising agents.

refrigeration	absorbing	oil
carbon	ships	methane
deforestation	rubbish dumps	

3

Some countries generate much more carbon dioxide than others. Study the table which shows the annual amount of greenhouse gas emissions by country then answer the questions.

a. Which country in the list is the largest producer of carbon dioxide per person? Why do think is this so?

b. How much carbon dioxide does each Maltese person produce on average?

c. Which country in the list produces least amount of carbon dioxide per person? Why?

d. Will the largest contributors to greenhouse gas emissions be the same ones to suffer most through global warming? Explain.

e. In the third column write the rank order, from 1 for the largest to 14 for the smallest contributors to CO_2 emissions per person.

f. Do you agree that there is a correlation between the affluence of the country and the amount of carbon dioxide it produces?

g. Many countries are trying to persuade the United States to reduce the emission of greenhouse gases. Do you think this is right?

h. China and India are fast developing. Why do you think is this worrying to scientists?

Carbon dioxide emissions
(in tons, annually, per person)

Country	Amount	Rank order
France	6.2	
China	4.6	
Brazil	1.9	
Japan	9.7	
Germany	9.9	
Mexico	4.2	
Pakistan	0.9	
United Kingdom	9.1	
Russia	11.7	
Sudan	0.3	
Zimbabwe	0.8	
India	1.3	
United States	18.8	
Malta	6.4	

4

a. Look carefully at pictures A, B, C and D.

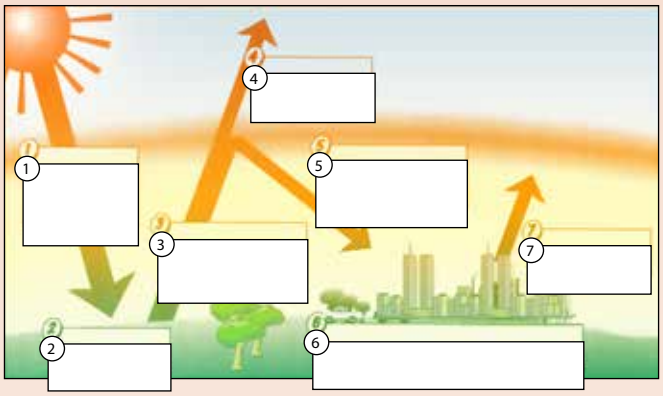
i. Which greenhouse gases are being produced by the activities shown in each picture?

ii. Explain how the increase in greenhouse gases as a result of these human activities is also increasing global temperatures.

iii. Suggest measures for reducing greenhouse gas emissions in each picture.

b. Study carefully the diagram on the right which shows the way global temperatures are increasing. Label the diagram with the terms given below.

- part of the heat is reflected back to space
- the land surface heats up
- carbon dioxide and other greenhouse gases trap the heat
- the burning of fossil fuels and deforestation increase the greenhouse effect
- temperature rises with the increase in greenhouse gases
- the heat of the land is reflected back into space
- the sun's rays penetrate the atmosphere and heat up the land



c. Write a report for a local newspaper to show that global warming is not a remote problem but is imminent. You can mention actual world problems such as:

- the retreat of glaciers
- heat-waves and forest fires
- Colder winters
- Extreme weather
- Hurricanes and devastating cyclones

5

a. What is the ozone layer? Mark the correct answer.

An atmospheric layer which absorbs all pollution emitted by human activities.	
An atmospheric layer at between 20 and 30 kilometres height which absorbs most of the sun's UV rays.	
A layer which traps and absorbs the sun's heat which is reflected back from the earth.	

b. Mention the chemical which is destroying the ozone in the stratosphere.

c. How does this chemical damage the ozone layer?

d. What is this chemical used for?

e. What would be the effects of the thinning and destruction of the ozone layer on people and on all creatures living on earth?

f. What measures have been taken by the countries of the world for safeguarding the ozone layer?

g. Do you think that the action taken were succesful? Explain.

6

a. These are the consequences which certain countries will face due to global warming. Read carefully.

Country or world region	Effect of global warming
Southern Europe	The Sahara Desert will advance into Spain, Malta and Greece.
The Maldives	These and other similar low-lying islands will be totally submerged.
Canada and Russia	Forest trees will dry out and die due to drought and heat.
Coast of Florida in USA	Hurricanes and flooding by tropical storms will increase.
Central and eastern Africa	Drought will increase and water will be scarce. Millions of people will leave their homes for lack of water.
North-west Europe	The Gulf Stream which carries warm water to North Atlantic will change its path and temperature will fall sharply.
Bangladesh	9% of the country will be inundated.
The Himalayas	Glaciers will recede and tourism will suffer.
Nile delta	A fertile land with high population density which may be inundated. Seawater will penetrate towards the valley and pollute the soil.
The Alps	Since there will be no snow, skiing resorts will close down.
The Mediterranean	Sandy beaches around the Mediterranean will be submerged when sea level rises.

i. On a world map mark all the places mentioned.

ii. Under each name write what may happen due to global warming.

iii. Give the following title to the map: *The Impacts of Global Warming.*

iv. Explain how global warming is expected to affect:
- sea level
- glaciers and Polar ice-cap
- the weather
- plants and creatures living on earth.

b. Global warming will also affect Malta. Answer these questions about the impact of global warming on Malta.

i. Maltese climate is expected to become drier and warmer. Explain how this change will affect:
- agriculture
- water resources
- tourism
- domestic electricity consumption.

ii. Experts hold that sea level will rise by 1 metre by 2100. What effect will this have on:
- tourism
- coastal zones
- aquifers in the rocks

iii. Global climate change is expected to bring about an increase in the frequency and intensity of extreme weather events. Explain how this might affect Malta.

7

Along the years many international meetings and conferences were held to control the problem of global warming.

a. Why is climate change considered a global problem?

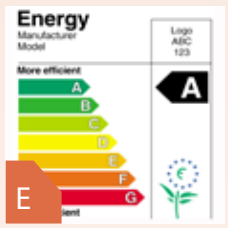
b. In 2016 The Paris Agreement was signed by 160 countries. Use websites to research what had been agreed at that conference.

c. Do you think other more ambitious targets should be set for the control of greenhouse gases?

d. Which would you say are the countries more responsible for global warming, the industrialised countries or those that are still developing economically?

e. What measures are being taken in many European Union countries, including Malta for the control of greenhouse gases?

f. The EU countries, including Malta, have agreed to reduce greenhouse gases by 20% till 2020. Use the pictures marked A, B, C, D, E and F to explain what concrete measures are being taken by EU governments to reach this target.



g. In Malta vehicular traffic is a major source of carbon dioxide and other greenhouse gas emissions. Write a letter to the Minister of Transport airing your views about measures which can be applied to reduce pollution by cars.

h. Imagine that you are a delegate taking part in a conference that will discuss climate change. You will represent one of the countries or organisations mentioned below:

- Kuwait, as an oil exporting country
- The Maldives, in the Indian Ocean
- Indonesia, a country that is industrialising fast
- Greenpeace, an environmental organisation
- A multinational car manufacturing company

In this conference a vote will be taken about a resolution proposed by certain countries so that carbon dioxide emissions will be reduced by 25% till the year 2025.

Take the role of one of the delegates and express your opinion, stating whether you will vote in favour or against the proposed resolution.

8

16% of greenhouse gases in the EU are produced in households. 70% of energy used in homes is for heating, 14% for water heating and 12% for lighting and electric appliances. On the other hand, vehicles are responsible for 10% of greenhouse gas emissions.

a. Imagine that you are an architect planning a house which will save as much as possible on consumption of electricity and water. What can you do to:
- reduce the penetration of heat and cold through the roof
- reduce the penetration of heat and cold through the windows and doors
- reduce the penetration of heat and cold through the walls
- harness rainwater
- allow for natural lighting in the rooms
- water heating
- generation of electricity

b. Mention five measures which each and every one of us may take in order to reduce electricity consumption at home or at school.

The lithosphere is the solid part of the earth's crust which is made up of rock and minerals forming the continents and the seabed. People use many resources found in this part of the earth. Rocks are used for building, glass making and for cement. In the rocks, one may find about 60 different types of minerals such as iron, copper, mercury and uranium. This last mineral is used for the generation of nuclear energy. Silicon which has become so important at this age is also taken from the rocks. This is used for making computer micro-chips, digital clocks, cellular phones and many other things. In between the layers of rock are found coal, gas and oil which are mostly used for the production of electricity.

The Formation of Rocks

3

Throughout the centuries, people have explored all corners of the earth. Humans have climbed the highest mountain, immersed into the deepest oceanic abyss, penetrated into the heart of the deepest tropical forest and reached the North Pole in the Arctic and the South Pole in Antarctica. Man has drawn detailed maps through which we can know the exact size and shape of all places on earth.

Since 1957 scientists have sent satellites to space. Every day these can send us detailed information about what is happening in all three major components of the world, that is the land, the oceans and the atmosphere.

The land surface is the solid part where we live. This is better known as lithosphere. On the other hand the hydrosphere includes all the seawater as well as freshwater which cover almost three-quarters of the earth's surface, while the air or atmosphere is composed of a number of gases.

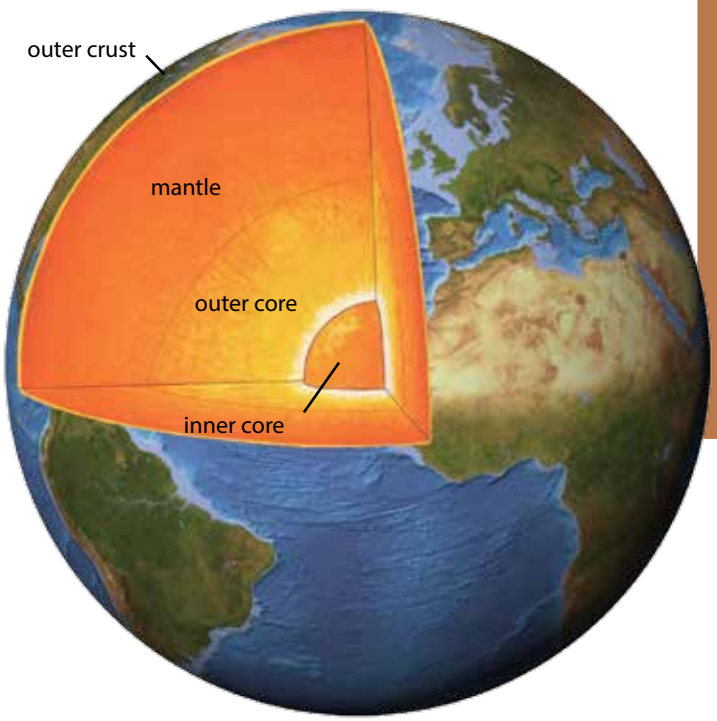
The hydrosphere includes all the water present in the oceans, seas, lakes, rivers, the soil, ice-caps and in the cracks in the rocks. The largest amount of this water lies in the oceans which cover 70% of the earth's surface with an average depth of 4 kilometres. The total amount of water in the world cannot change but there can be differences in the state of water. When it freezes and becomes ice, it takes solid shape. It is in liquid state in the seas, rivers and in clouds. In the air there is also water-vapour in the form of gas. Without water life on earth would not have been possible.

The interior of the Earth

When did our world form? How did it form? What is it made of? These are some of the questions which geologists try to answer while studying the earth's surface and the forces which act to shape it. The geologist's job is to explore the story of the earth since its beginning, much earlier than the development of early man. The information and evidence of what happened millions of years ago lie in the rocks.

The earth is made up of four different layers. On top one finds the solid crust of the earth, made up of rocks and minerals which together form the continents and the ocean beds. The crust is the thinnest layer, 5 km deep under the oceans and up to 70 km under the continents.

Right beneath the crust there is the mantle which is about 2,900 km thick. Here temperature reaches 1,600°C. This layer is mostly composed of magnesium and silicon. Although some parts of the mantle are hard and solid, most of it is semi-molten.



In 1909, Andrija Mohorovičić, a Croat seismologist, discovered that seismic waves increased in speed and changed direction when they reached a certain level in the lithosphere. This discontinuity lies about 45 to 70 kilometres below the earth surface and it constitutes the dividing line between the earth's crust and the mantle. This is today called Mohorovičić or Moho discontinuity. In 1961, scientists started drilling a hole down to the Moho in order to learn about the structure of the earth. The place chosen for Mohole, as this ambitious project was called, was the Pacific Ocean off the Mexican coast. There the mantle is only 5 kilometres below the ocean bed. But after 5 years of drilling the project had to be abandoned for lack of funds.

In 1983, the Russians started their own project, this time on land, at Kola Peninsula, close to Finland. Their aim was to reach the Moho and the mantle and to extract rock samples. The rig started drilling in 1970 and continued for 24 years until 1994 when the project stopped at 12 kilometres deep. Until now this is the deepest borehole ever drilled by man. The project was stopped since the machinery became increasingly hot and faulty as the lower layers were reached.

Deeper down one finds the earth's core which is most probably composed of nickel and iron. The outer core which is about 2,200 km thick is molten, while the inner core is solid with a temperature of about 6,000°C. This means that the deeper and closer one gets to the centre of the earth, the higher the temperature.

The picture below shows the Japanese ship Chikju Hakken (*Discovering the Earth*) which holds the most modern apparatus for drilling and extracting rock samples from underground. Scientists from all over the world are collaborating in order to better understand the earth's structure and what types of rock and minerals are found thousands of kilometres deep.

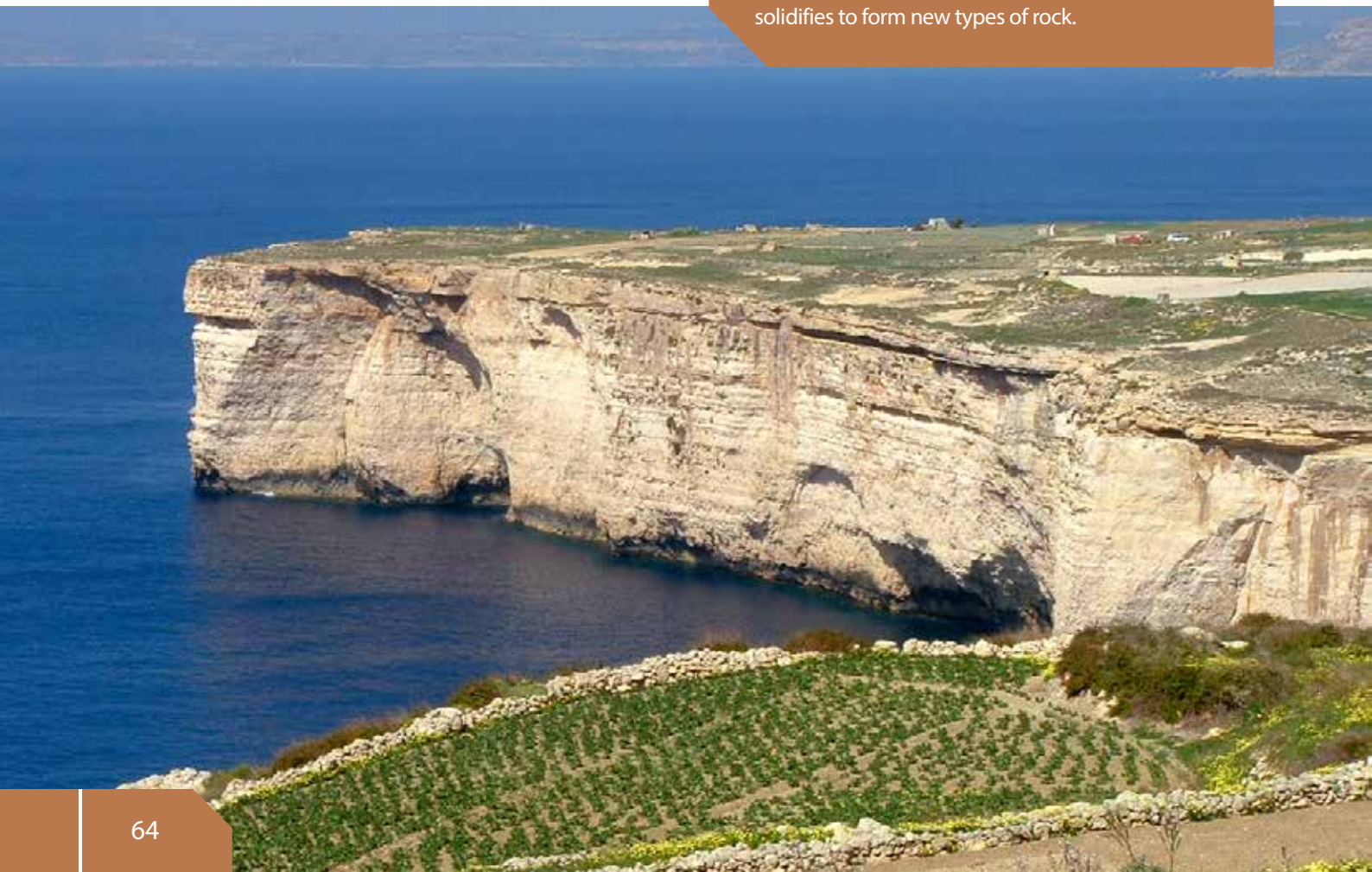
Geology, that is the study of rocks, is becoming more important today. Detailed geological studies of any place will help determine whether new deposits of indispensable minerals and metals such as oil, uranium or gas are present. Information about the type, depth and strength of the rock is also necessary before large infrastructural projects are started, like the digging of deep mines and boreholes for water, the building of large dams across rivers, and the construction of tanks for oil and gas storage.

Rocks - prime raw materials

The lithosphere is composed of different types of rock. These can be very hard like granite or somewhat soft like clay. Rocks also vary in colour or weight. Rocks are made of a mixture of minerals which are so minute that they are only visible through a microscope. Some minerals found in rocks are important for the economy since they contain metals such as iron, tin and silver. One also finds other colourful minerals in the rocks that are polished to be sold as precious stones.

In all countries rocks are used for raw materials. Building stones, spalls and building sand are produced from quarries. Rocks hold so many minerals that are necessary for the economy of many countries. Moreover rock weathers naturally and becomes dust after thousands of years. In this dust, or rather soil, the farmers cultivates the crops. Rocks are important for water extraction. Rainwater infiltrates the cracks in the rock and settles within the pores of porous rock. Even the coastal rocks are weathered. They firstly weather into pebbles which later become sand. Sandy beaches attract many tourists.

Rocks form part of a cycle, like water. In time rocks are weathered, broken and eroded through the direct effects of the rain, wind, sea, weather and other agents. Rock particles are transported and deposited into the sea. By means of its own weight and pressure this material consolidates and solidifies to form new types of rock.



Igneous rock is volcanic. In fact the word 'ignis' means fire in Latin. There are two types of igneous rock. In the picture above one can see extrusive rock, like basalt, which was emitted after a volcanic eruption. On the other hand, granite rock, such as the slabs shown below ready to be shaped into pavements, is intrusive rock since the magma which formed it cooled and solidified underground. Granite is much sought since it is hard and colourful. In Malta it is used in the houses for the stairs and for kitchen covers. Abroad it is used for pavements and crushed into spalls for road-surfacing.

Not all types of rock are formed in the same way. Igneous rock is formed by volcanic activity. This rock is made of molten material called magma which is found in the mantle beneath the earth's crust. When some of this material is emitted on to the earth's surface, it cools quickly and forms such rocks as basalt, lava and obsidian. On the other hand when the magma does not reach the surface it cools slowly and solidifies forming rock types such as granite.

Sedimentary rock is made up of particles of other older rock. The older rock is weathered and eroded by the elements until it is transported into the sea by the wind, rain or rivers. These particles are joined by the remains of sea creatures. These particles deposit in layers on the sea-bed. By means of its own pressure this sediment is pressed to form new rocks.

Clay, chalk and limestone are examples of sedimentary rock. Since these were all formed under the sea, in them are found a lot of fossils.

Sedimentary rock such as chalk (in the picture above) and clay (in the picture below) is made up of remains of sea creatures, among other things. Chalk is not used for building since it is soft, weathers and dissolves easily in water. This whitish rock is used in the production of cement.

When igneous and sedimentary rocks are exposed to great pressure and heat, they change their structure and form becoming metamorphic rock. This usually happens due to earthquakes or volcanic activity nearby.

Often during such process of change, metamorphic rock becomes stronger and more resistant.

Here one can see two types of metamorphic rock, marble (above) and slate (below). This is rock which changed its form. In fact the word metamorphosis means change. Marble which is derived from limestone, is crystalline rock with beautifully coloured veins. Since it becomes bright by polishing it is used for sculpture and house decoration. Slate which is derived from clay is blue-grey in colour. It is easily cut in thin sheets or layers without breaking. Sheets of such rock were used to cover roofs of houses abroad.

The Geological History of the Mediterranean

All the rocks in Malta is sedimentary having been formed under the Sea of Tethys. The Mediterranean Sea of today is the remnant of this large sea which existed between 300 and 65 million years ago.

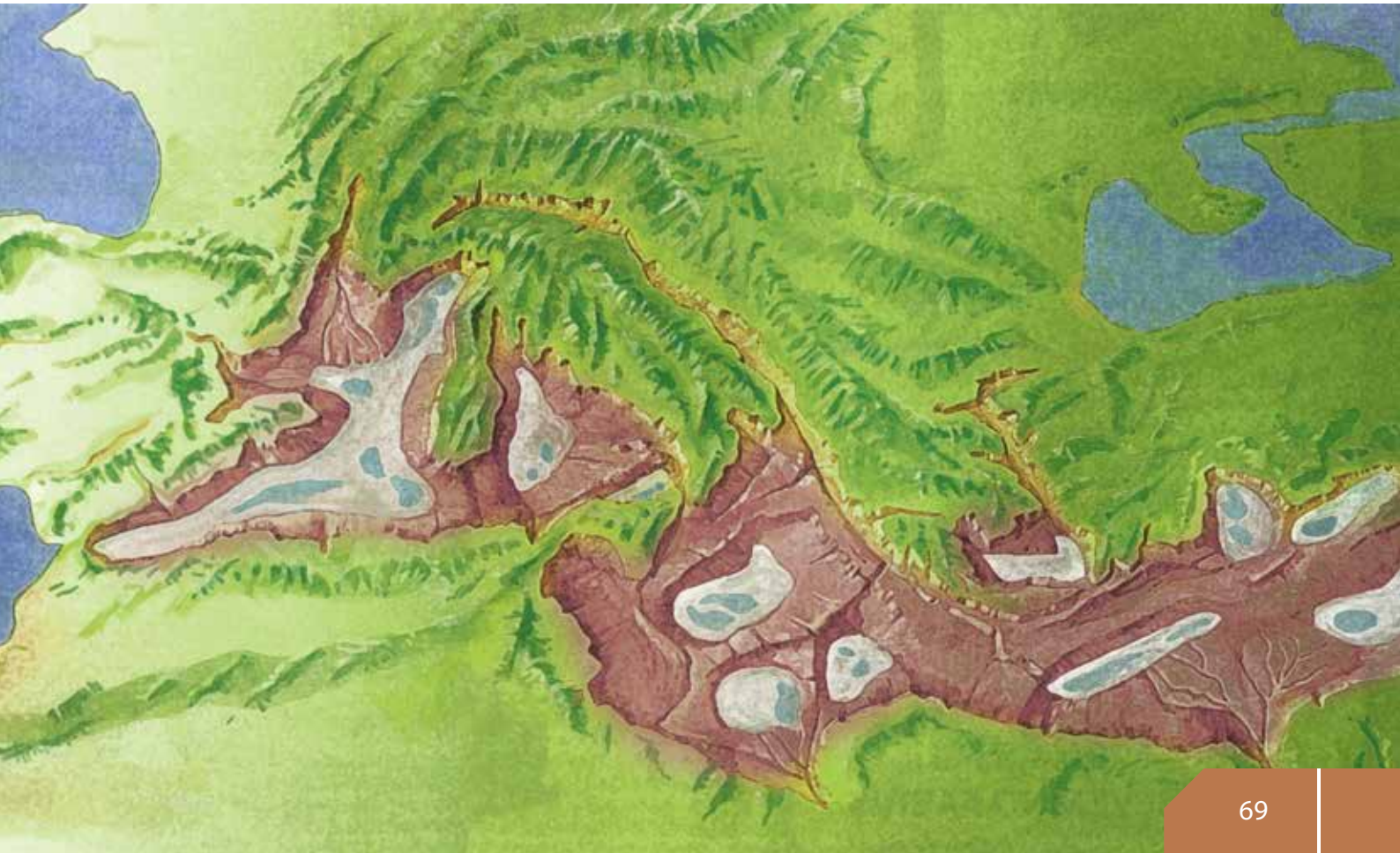
The Sea of Tethys extended from the present day western limits of the Mediterranean towards the east joining the Indian and the Pacific Oceans. One can say that it was a large ocean surrounded by land. Many rivers used to transport and deposit their sediment into this ocean. Along the years the bed of this sea was covered with layer upon layer of sand, pebbles and other sediment. Sea creatures as well as river silt also deposited there.

About 55 million years ago movement of the earth's crust started to close the Sea of Tethys. This movement closed the Sea of Tethys in the east but opened a strait in the west. At the same time and for the same reasons, mountain chains emerged and formed along the coasts of the Mediterranean, such as the Alps in Europe and Atlas Mountains in North Africa.

The Mediterranean changed its shape through the ages as can be seen in the maps on the right. More than 200 million years ago the Mediterranean was a very large sea extending from the Atlantic to the Indian Ocean. Geologists call it by the name of Tethys. Due to strong currents moving under the earth's crust the Mediterranean slowly changed its shape to that which it now has. Africa moved towards Europe and this way the Mediterranean was cut off from the Indian Ocean. About 7 million years ago the Straits of Gibraltar was closed and the Mediterranean started to evaporate at a fast rate. It was landlocked for a very long period such that many areas dried up completely. The strait between Spain and Morocco opened up again about one million years later and the sea inundated the Mediterranean area once again.

This movement was continuous and about 10 million years later other movement in the central Mediterranean caused a mountain ridge to emerge from south-east Sicily towards Tunisia. This is how Malta emerged from the sea.

It is difficult to imagine how the Mediterranean dried up when one considers that it is 1.5 km deep and in some places even 3 km. There are large deposits of salt on the seabed of the Mediterranean as shown by the American research ship Glomar Explorer. Nowadays, scientists believe that after the closing of the Straits of Gibraltar the Mediterranean had turned into a series of salt lakes.



About 7 million years ago strong tectonic movements caused Malta to emerge from the sea. Sometime later the Mediterranean waters started to evaporate and the level of the sea lowered forming low lakes or even uncovering the bed. Some think that the Mediterranean was completely dry. This happened when the Straits of Gibraltar from which a cold current used to eneter the Mediterranean, closed. This was the first time that Malta was joined to Sicily and animals which lived in Europe crossed over. Suddenly the strait between Spain and Morocco opened up again and large amounts of water penetrated the Mediterranean basin. It took more than a century for the previous level of the Mediterranean Sea to be reached. The sea replenished with fish and other marine creatures. Meanwhile Malta became an island once more.

The river silt and marine creatures deposited on the bed of the Sea of Tethys emerged when Africa moved towards Europe. Due to this movement mountain chains emerged around the Mediterranean such as the Alps in Europe. These mountains are made up of sedimentary rock which formed under the Sea of Tethys. This sediment accumulated on the seabed until 7 million years ago when further movement caused Malta to emerge.

Life in the Sea of Tethys

The large number of fossils derived from marine plants and creatures is clear evidence that Malta was formed under seawater. Through these fossils one can have a glimpse at life under the Sea of Tethys between 30 and 6 million years ago, the period in which the Maltese Islands were formed.

Fossils are the remains of creatures that lived millions of years ago and which were preserved when they were covered by silt, and other sediments. The soft parts of these creatures rotted away. However, the harder crust or parts such as teeth and bones remained in the rock for a long time and preserved their shape. In the early Mediterranean Sea there surely lived many octopus, squids, jellyfish, sea anemones and worms. Since these creatures have no bones they left no trace once they died and in the rocks of Malta one does not find any remains but they must have played an important role in the food chain of the Sea of Tethys.

Fossils of sea urchins which lived on the bed of the Sea of Tethys are easily recognisable since their shell is usually divided into five parts.

Buried in Malta' s rocks one can still find fossils of creatures that are similar to those which still inhabit the Mediterranean Sea. Such fossils give us an idea of how these creatures evolved throughout this long period. Fossils of creatures which no longer inhabit the Mediterranean Sea are also found. Such species can now be found living in warmer waters like the Red Sea. There are also fossils of totally extinct marine plants and creatures now living nowhere on earth.

The most common fossils found in Malta's rocks are those of molluscs such as shells, snails, oysters, mussels and date-shells. Most commonly one finds the form of these creatures. However, the whole crust can also be found usually divided into two parts.

Whales and dolphins were common in the Sea of Tethys. Jaws armed with pointed teeth and molars as well as spinal cords of these large vertebrates were found.

Long ago in the Sea of Tethys lived a great variety of fish species of different size and shape. In Malta's rocks were found complete shapes of fish as well as bones and other remains of cartilaginous fish such as sawfish, rays and long-nosed skates. In the different layers of Malta's rocks fossils of diverse species of sharks were found, such as the porbeagle-shark, hammerhead-sharks, small-spotted dogfish, and white shark. Spinal cords and pointed and serrated teeth of such sea predators were found. The largest tooth found till now is a 16-centimetre tooth of a white shark!

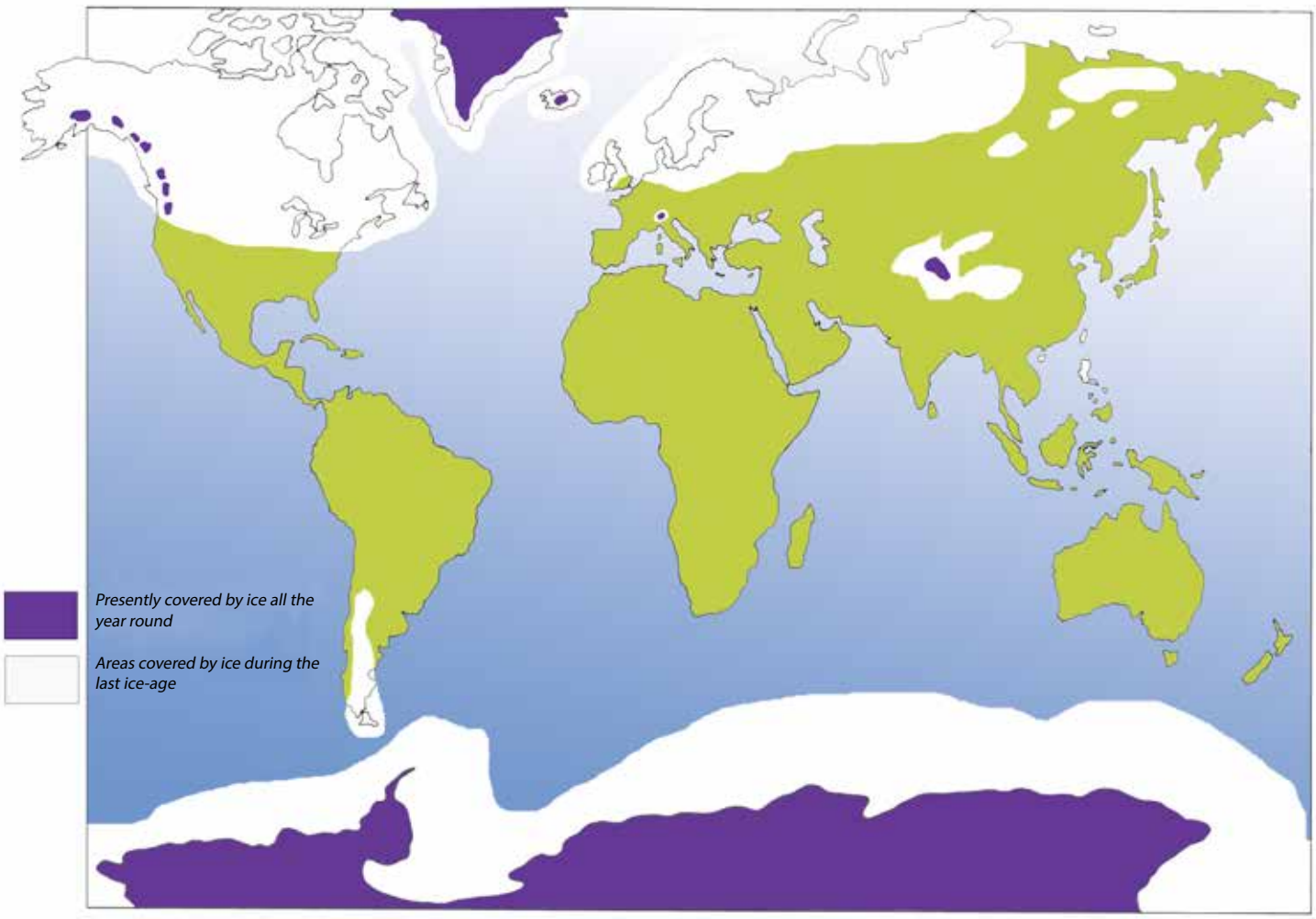
On Tethys' seabed lived many urchins and sea-stars which have pointed crusts as well as other creatures like corals and sponges. These creatures used to cover the sediment at the bottom of the Sea of Tethys and many of their fossils have been found in Malta's rocks.

Large reptiles and mammals could be found in the Sea of Tethys which nowadays no longer inhabit the Mediterranean. There were large turtles and crocodiles as well as different species of monk seals. Many of these can no longer be found in the Mediterranean but only inhabit warmer seas. Only one species of monk-seal can be still found in the Mediterranean, albeit rare.

Malta during the Ice-Age

About 2 million years ago during the ice-age the sea level lowered once again and Malta was again joined to Sicily. Sea-level fell by about 120 metres because climate changed. Temperature decreased and great quantities of seawater froze in the northern parts of the world.

Same as had happened before, many animals migrated to the South of Europe in order to avoid the harsh cold climate of those places. They managed to come to Malta but not to Africa since the sea level did not fall enough to uncover the seabed between these places. A large number of hippopotamus, dwarf European elephants and other herbivores such as deer crossed over to Malta in order to find enough pasture. Meanwhile carnivores like bears, foxes and wolves would wreak havoc on the herds of deer which came from the north. The bones of these preys, as well as live animals, would be carried by flooded rivers especially in the inter-glacial periods.



The ice-age started about 2 million years ago at the beginning of the Pleistocene period and since then there have been 4 very cold periods called glacial periods, when ice advanced everywhere. In between ice-ages, there were warmer periods, called inter-glacials when ice would thaw. The last ice-age started about 70,000 years ago and ended about 10,000 years ago. During that time about 30% of the world's land area was covered by ice which reached a thickness of 2,500 metres in some areas. As can be seen in the map, the Mediterranean was never covered by ice, however, it is certain that its climate was much colder and humid than today.

This is why so many bones of such animals were found among rocks and debris in certain caves like Għar Dalam, and Għar Magħlaq as well as in cracks in the rock.

Conditions returned to normal about 10,000 years ago at the end of the last glacial period. Malta became an island since the sea level rose again with the difference that so many animals from Northern Europe were stranded on the Maltese Islands.

The Maltese Islands were too small for the needs of all these herds of animals and there was not enough food for them. Under these unfavourable conditions many of these animals became extinct in a short time. The only evidence left of their presence in Malta are the fossils which were discovered at Għar Dalam and in other areas.

In the museum at Għar Dalam are exhibited fossils of the Pleistocene age which were found in Malta. These include remains of dwarf elephants, hippopotamus, wolves, deer, foxes, very large turtles, large lizards, swans and aquatic birds.

Among the animals that lived in Malta there were three species of dwarf elephants. The largest one was two and a half metres (see the picture below) while the smallest one stood only 90 cm tall. There were also some hippopotamus species which were also smaller than their European relatives. Deer could be found roaming and grazing in the Maltese landscape. Like the species even the deer were dwarfs. From their study it was found out that their legs were shorter but sturdier than those of today's deer.

While some animals that lived in Malta became smaller in size, others became larger. Among these species one can mention lizards, mice, which became larger than rabbits, land turtles and aquatic birds like the swan.

Sedimentary Rock of the Maltese Islands

The Maltese Islands are composed of sedimentary rock which was formed under the seawater of Tethys. This began to form about 25 million years ago out of remains of sea creatures, sand and silt. Fifteen million years later tectonic movement lifted the sediment that was on the seabed and thus the Maltese Islands emerged above the surface.

The Maltese Islands are made up of five main types of rock, which are the following from lowest to highest: lower coralline limestone, globigerina, blue clay, greensand and upper coralline limestone.

Malta's rock is formed of five horizontal layers, each one on top of another and the oldest layer is the lowermost, that is, the lower coralline limestone. This does not necessarily mean that all the five layers can be found everywhere. For example at Baħar iċ-Ċagħak there is only one layer and the others are missing.

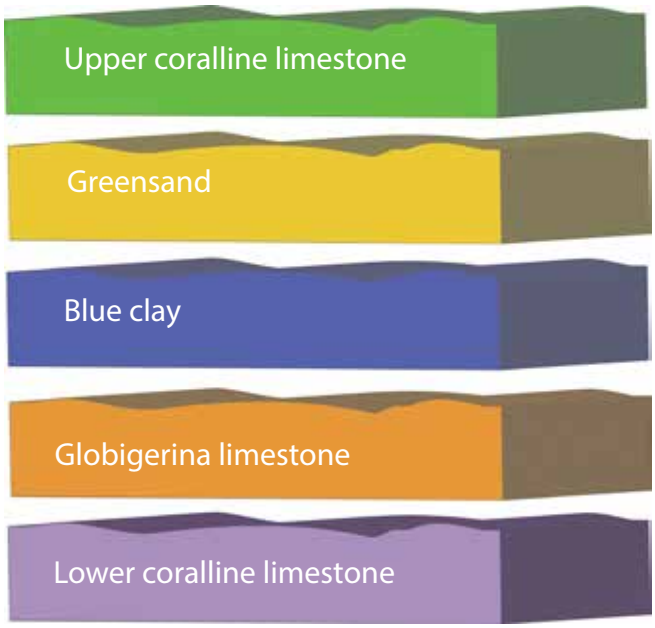
On the other hand in the major part of the western Malta such as at Ras il-Qammieħ all five layers are found, each one lying on top of another.

The five layers of rock in Malta are quite different from each other. Each layer has its own charcteristics including colour, porosity, hardness and weight, among others. This difference in composition is the result of changing conditions on the seabed at the time of rock formation. The climate on land changed whenever there were pluvial periods with much rain, increase in deposition of different particles and sediment, or when there were dry periods. The difference in climate affected the thickness of the layers. There were also changes in the depth of the seabed and changes in the temperature of the sea, and these differences also determined the fish and marine plants and creatures that lived in the Sea of Tethys. It is precisely because of all these changing factors that we now have five different types of rock in Malta.

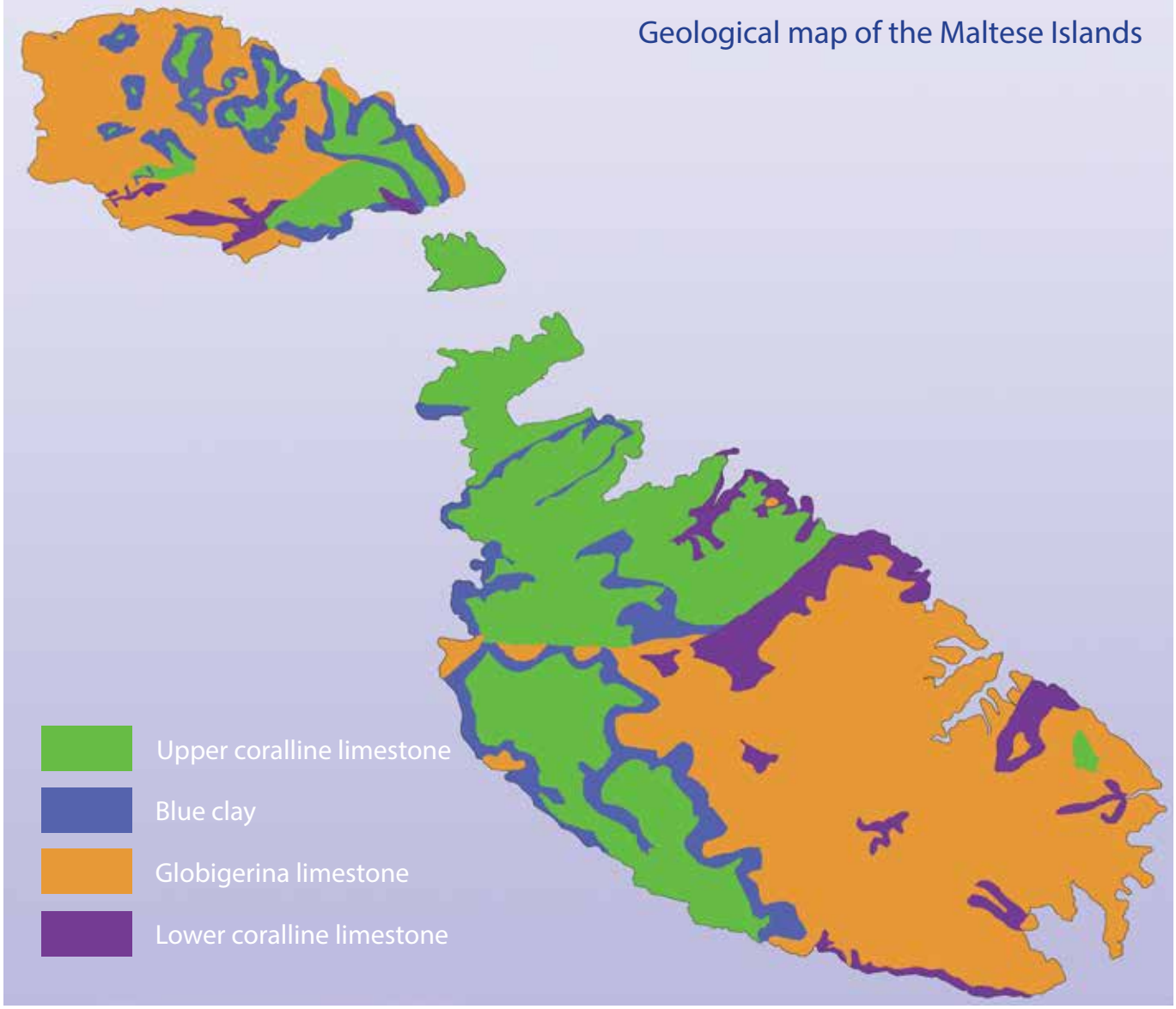
In certain areas of Malta there are quaternary deposits which contrary to the other five main layers of rock, were deposited when Malta was already an island. This layer is composed of a thin layer of pebbles and large stones conglomerated with a certain amount of blue clay and terra rossa soil. This material was weathered and transported by rainwaters that were very abundant about one and a half million years ago.

The geological map shows the distribution of different types of rock found at the surface. A different colour is used for each type of rock. The greensand layer is not visible in the geological map since this does not exist at the surface, neither in Malta nor in Gozo.

In the drawing to the right we can see the rock stratigraphy of the Maltese Islands. It is made up of beds or layers laid out one on top of each other. The oldest layer, that is the one which was formed first at the bottom of the Sea of Tethys is lowermost, while the one at the top is most recent.

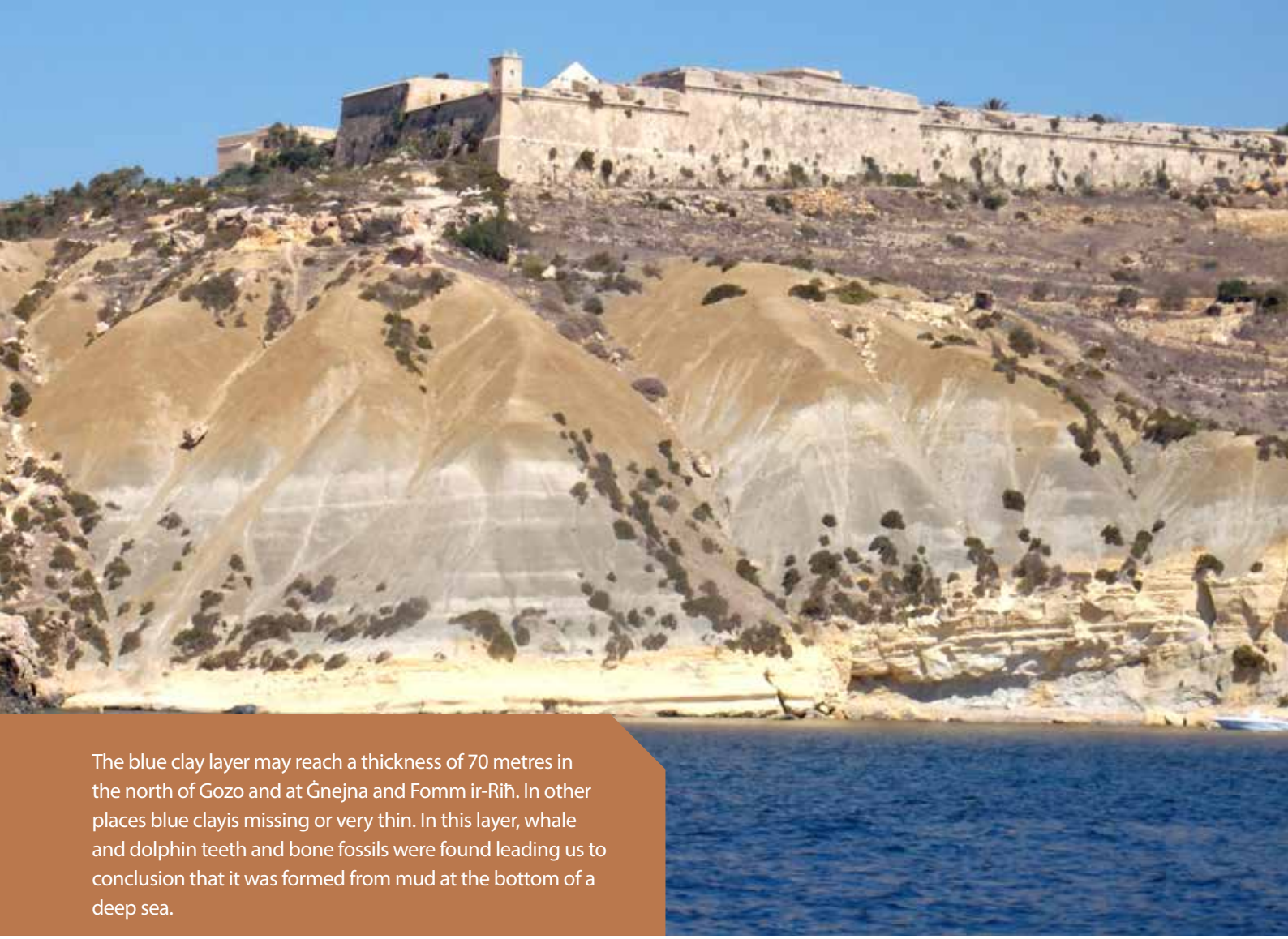


Geological map of the Maltese Islands



Over the blue clay we find the greensand layer, 'rina' or 'ramli', in Maltese. It is called so because it is distinguishable by its particles of greenish mineral called glauconite. When this layer is exposed to the elements it changes its colour to yellow and sometimes even to orange (as can be seen in the picture below). In the past pieces of this stone were collected to be used as blotting material for ink. Greensand is a very grainy and porous rock almost totally made up of the broken shells of marine organisms. This sandy rock is not always found between the blue clay and the upper coralline limestone and often it is only about 1 metre thick. The thickest layer of such rock is situated on the

slopes of Gelmus Hill in Gozo. In this layer one can find a large amount of fossils of creatures that inhabited the bottom of a shallow and sandy sea like starfish, urchins and molluscs.



The blue clay layer may reach a thickness of 70 metres in the north of Gozo and at Ġnejna and Fomm ir-Riħ. In other places blue clayis missing or very thin. In this layer, whale and dolphin teeth and bone fossils were found leading us to conclusion that it was formed from mud at the bottom of a deep sea.

Above the globigerina limestone one finds the layer of soft blue clay. On the practical and technical aspects, this thin layer is of utmost importance for Malta. While globigerina limestone and coralline limestone have provided the Maltese with building stone, blue clay helped the Maltese settle on the islands since clay is the only impermeable rock layer in Malta. Due to this, infiltrated rainwater settles inside the pores of the layers above thus forming the perched aquifer. Moreover at the blue clay outcrops, natural springs formed which provided a much needed ready source of water.

Maltese clay has been worked since prehistoric times. Large amounts of locally-manufactured clay ornaments, statuettes, vases, plates, amphorae, basins and other objects were found in many prehistoric sites.

Pottery was used in olden times to manufacture many objects such as plates, pans, saucepans, vases, and pipes. Pottery is none other than clay baked in an oven. In the picture below we can see clay being shaped before being placed into the oven.

Lower Globigerina Limestone – a soft stone for building

The globigerina limestone layer forms the surface rock or outcrop of 70% of Malta's territory and forms large plains. In some areas there are cliffs made of this rock. The rock is formed out of shells of marine creatures called foraminifera globigerina. In certain samples that were studied the shells of these microscopic organisms amounted to 80% of this rock.

The globigerina limestone layer is between 23 and 207 metres thick and is sub-divided into three sub-types or members. These are the upper, middle and lower globigerina limestone.

Under the first and second layers of globigerina one finds two beds of conglomerates made up of shiny-brown, round and oval pebbles. These pebbles have a large amount of calcium phosphate mixed with shells of many marine creatures. In the picture we can see a thin conglomerate bed between two layers of globigerina limestone. The uppermost sub-layer or member of globigerina is called upper globigerina limestone. This rock is fire-proof and in the past the Maltese used this sub-type to build their ovens. Small stone-stoves were also made out of the upper globigerina, since as already noted it is highly resistant to heat. The central sub-type is called middle globigerina limestone. This whitish layer is the softest of globigerina and is easily weathered and eroded. The lower globigerina limestone is used for building. This is softstone that is easily cut and dressed but weathers well and hardens once exposed to the air.

Over the centuries, Malta was ruled by large empires and countries which left their mark on the Islands' history. The first inhabitants of Malta who came about 7,000 years ago, used the raw material they found at the surface. With great skill they cut the rocks and built kilometres of rubble walls to separate the fields. They built the magnificent megalithic temples and sculpted statuettes in great detail, using globigerina or coralline limestone. Rulers of the Islands, including the Knights of St John and the British directed the skilled Maltese stone-masons to build whole towns and cities surrounded by high fortifcation walls and bastions, to defend the churches, cathedrals, towers, and barracks, with lower globigerina limestone.

Most of the houses in Malta are built with lower globigerina limestone, tal-franka, in Maltese, The excavation of this type of rock in the quarries generates a lot of construction activity. Apart from quarrymen, haulage contractors, stone-masons, plasterers and tile-layers depend on quarrying for their work.

Lower Globigerina Limestone

Lower globigerina limestone is rich in fossils. In this layer sharks' teeth, large snails with decorated shells and smaller ones with spiralled shells called scalaria were found. Remains of fish, sea urchins, molluscs, sea turtles crocodiles and seals were also found. In the lower globigerina limestone one finds finger-like fossils. These are tunnels burrowed in the sand and mud by marine creatures for their own protection.

Globigerina limestone is made up of silt and creatures which lived in the Sea of Tethys between 20 and 8 million years ago. In this layer we find fossils of decorated or spiral shells. Remains of crocodiles, seals were found, as well as large teeth of large sharks that are now extinct.

In the past the excavation and cutting of stone in quarries used to be done with hand tools. Nowadays this same work is done more quickly and with less fatigue with the use of machinery. Two main machines are used, the trench machine which cuts the stone from above according to the depth or height of stone required; and the lower machine which cuts the stone horizontally. Meanwhile fine dust is produced called fine stone dust, xaħx in Maltese, which is mixed with cement and water to form mortar which is used by the stone masons during construction.

In places where globigerina outcrops, that is, lies at the surface, we find quarries where building stone is excavated. In Malta these globigerina quarries are mainly found at Mqabba, Siġġiewi, and Żurrieq, while in Gozo they are located around Dwejra at San Lawrenz and Kerċem. Lower globigerina limestone is a softstone and is easily excavated and dressed. A look at Malta's buildings inspires admiration for the beauty of this stone, worked up or sculpted into statues, sculpture, balustrades, arches, columns, corbels, roundels and many other motifs.

The quality of lower globigerina limestone varies bewteen one locality and another. For example at Mqabba the globigerina is yellowish in colour, weathers and hardens well. At Siġġiewi the globigerina is pure white and is sought after for sculpture or building facades that are left unpainted. On the other hand the globigerina that is quarried from San Ġwann area can withstand salty conditions near the coast and will be hard to erode there.

Coralline Limestone - a hard and strong Rock

The topmost and the lowermost layers of rock found in the Maltese Islands, called coralline limestone, are also the hardest. Upper coralline limestone was the last layer to be formed on the seabed of Tethys. This type of rock is now found in the highest places of the Maltese Islands at Mellieħa and Dingli in Malta, as well as in Xagħra and Nadur in Gozo. On the other hand the lower coralline limestone is the oldest rock in Malta since it was the first to be formed at the bottom of the sea between 35 and 25 million years ago.

Lower coralline limestone is is found at the surface where the layers above it were eroded in time. Thus we find it on the coast at Baħar iċ-Ċagħak and at Xgħajra, as also at Ta' Ċenċ and Fomm ir-Riħ cliffs where it reaches a thickness of 140 metres.

The strength and hardness of this rock varies considerably. Lower coralline limestone is precisely semi-crystallised stone that is hard, heavy, very strong and almost impermeable. On the other hand, the Għajn Mellel member or sub-type of upper coralline limestone is very soft, light and porous resembling chalk.

Upper coralline limestone resembles the lower coralline. In fact this type of rock is sometimes hard, compacted and crystallised. At other times it is composed of softer rock which is easily weathered. Even the colour varies. Some layers are greyish-white ,while others are yellowish or ruddy (red). On the hills and cliffs the upper coralline limestone has an average thickness of 30 metres. However, at a borehole in Binġemma a thickness of 162 metres was registered. At the surface of this rock one finds a very hard crust which was formed during dry and hot periods.

In between the lower coralline limestone and globigerina limestone layers one can find a bed full of sea urchin remains called scutella subrotunda (picture below). It seems that this urchin was quite abundant at the time this rock was formed since so many were found. Large areas replete with fossils of such urchin, which is now extinct. These can be found at Qammieħ and along the coast between Wied l-Għasri and Xwejni in Gozo.

The water which was stored in the rock was evaporated at a fast rate by the extreme heat and the pores of the rock were filled with calcium carbonate (C_aCO_3). This hard crust is much sought by building contractors since it provides raw material for high quality spalls. Although most layers were crystallised and therefore lost traces of life, the lower layers are softer and therefore preserve a large number of fossils, including sea snails, molluscs, urchins and crabs. This shows that the upper coralline limestone was formed under a shallow and warm sea near to the coast.

Coralline limestone comes in different sub-types. Normally the *qawwi tal-prima* is compacted, hard and sturdy. Howewver the *qawwi tas-sekonda*, especially the Għajn Mellel member or sub-type, is whitish in colour, porous and easily eroded. Coralline limestone quarries are obviously found where the rock outcrops, that is, lies at the surface, such as at Mosta, Qrendi, Mellieħa and Dingli in Malta, as well as at Għajn Abdul and Għar Dorf in Gozo. In olden times coralline

In the coralline limestone layers, many fossils of algae and corals are found. These take up calcium from seawater in order to build their own calcareous shell. Coralline limestone is made up of algae reefs that formed in a clear, shallow (not more than 50 metres deep) and warm waters with temperatures always above 20°C, hence their name, since they are made up of coralline algae. This means that at the time when these two types of rock were forming, the conditions of Tethys Sea were very similar to those of the present day Great Barrier (coralline) Reef of Australia.

limestone was used to lay pavements, for stairs and for simple monuments. This rock can be polished. In this case it is then called Maltese marble. This is not really marble though, since marble is a metamorphic rock of which Malta possesses none. But since this is a hard and shiny stone, it is similar to marble.

When Malta was ruled by the Knights of St John, many coralline slabs were used to lay the pavements in Valletta. In fact many of these slabs can still be seen especially in front of palces and auberges built under the Knights' direction.

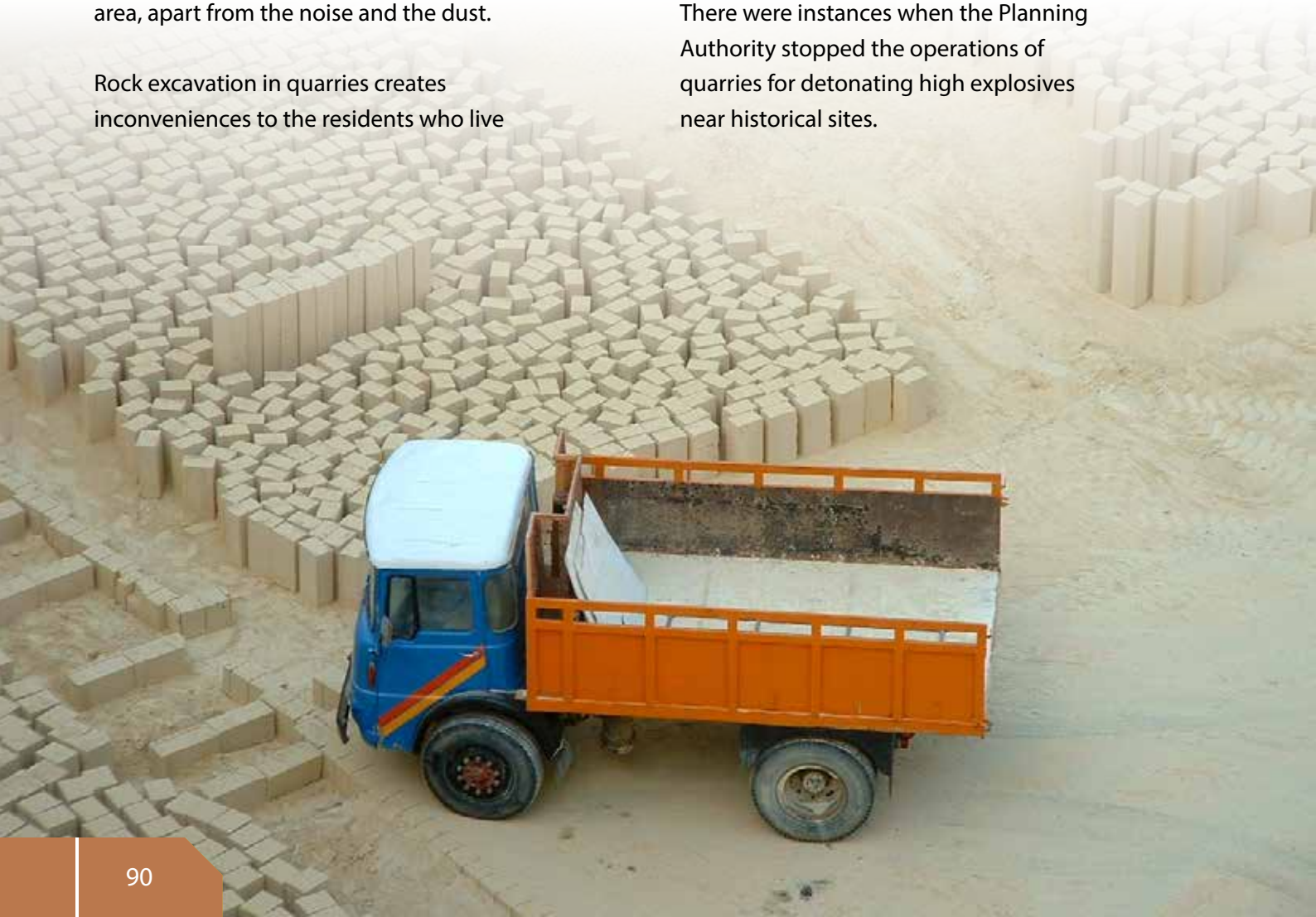
As can be seen in the picture below, in coralline limestone quarries, the rock is excavated by means of dynamite. Machines will then break it up into smaller pieces which are then dropped into a crusher that grinds them into spalls or building sand. Spalls derived from lower coralline limestone is much sought for the production of pre-fabricated concrete roofing and for street tarmac, concrete and bricks. The upper coralline is used for the production of lime.

The Impact of Quarrying

Rock is a non-renewable resource. In Malta coralline limestone is mainly excavated for producing concrete, while globigerina limestone is cut into building blocks of stone. Quarrying is crucial for the construction industry which depends on it.

Rock quarries leaves a great visible impact on Malta's landscape. All quarries combined take up about 2.3 km^2 or 0.7% of the Islands' territory. To these must be added the disused quarries that are now only big hollows in the ground. Many quarries lie near to residential areas and their negative impact is felt mostly by the neighbours. Large stone and spalls laden trucks adds pressure to the transport system of the area, apart from the noise and the dust.

Rock excavation in quarries creates inconveniences to the residents who live close. Globigerina stone is cut by means of large bent-saws that produce large quantities of fine dust which is carried by the wind on to the residential zones. The same happens at coralline limestone quarries. The explosives used to break up the rock also produces dust or even moves other dust that had already settled. This can damage buildings and other property or even archaeological or historical sites. There were instances when the Planning Authority stopped the operations of quarries for detonating high explosives near historical sites.



The areas mostly affected by this industry are Siġġiewi, Żurrieq, Dingli, Mqabba and Mosta in Malta, as also Dwejra in Gozo. Quarries are situated quite close to residential zones. Consequently their impact is greatly felt by the people who live close to them.

The use of dynamites in coralline quarries can also cause irreparable damage to the water table in the underlying layers of rock. Farmers and quarry owners sometimes are at conflict due to this problem. Farmers complain that the excavation and shaking of rock blocks the natural passage of groundwater which will become scarce or even totally lost for irrigation.

Some quarries cause great desolation in the neighbouring areas. Tons of stone chippings, building sand and other material are carried by rainwater or the wind into nearby valleys. Thus building sand and spalls from the mounds stored in the quarries ultimately ends up into the valley bed. Slowly most creatures in the valleys die out.

Along the years, a number of old and disused quarries have been rehabilitated. Some of them have been filled up with construction waste and later covered with a soil layer for agricultural use. Others have been directed for industrial use having concrete batching or tarmac plants. Others have been turned into large reservoirs for rainwater storage which is then used as second-class water.

Coralline limestone (hardstone) quarries are damaging the ecology of the garrigue where they mostly operate. Due to the large demand for spalls these quarries have to expand horizontally since the best quality *qawwi tal-prima* rock type is only found near the surface. Large expanses of garrigue have been destroyed in Dingli, Għar Lapsi and Qrendi as well as on the hills of Naxxar and Mellieħa by the quarries themselves and by the fine dust that flies on to the areas nearby. Għajn Abdul hill has been dug up almost totally and little is left of the original natural garrigue environment. At Nadur hill scrub vegetation such as thyme, spurge and hawfinch have been destroyed. Not even the garrigue coast of Qala was spared the ravages of the hardstone quarries there! Because of quarrying many indigenous flora have become extinct and other are threatened. For example an orchid species which only grew at Wied il-Għasel has now become extinct.

In order to meet the big demand the cutting of stone from quarries has increased in the past few years. For example in 1957 only 5% of Malta's territory was built up. Forty years later this percentage went up to 20%. Apart from this, one has to keep in mind that many houses are now being demolished to make way for apartment blocks. According to estimates, rock for building will be exhausted in due course if the current rate of extraction is maintained. Softstone globigerina will last for 300 years while hardstone coralline will be finished in a 100 years' time. This estimates includes resources that are found in areas of great environmental value. We need to save on this resource by reusing stones rather than discarding them. For example the stone blocks of old houses which are about to be demolished can be used for the foundations of new buildings, for the restoration of old ones or for mooring floats of fishermen.

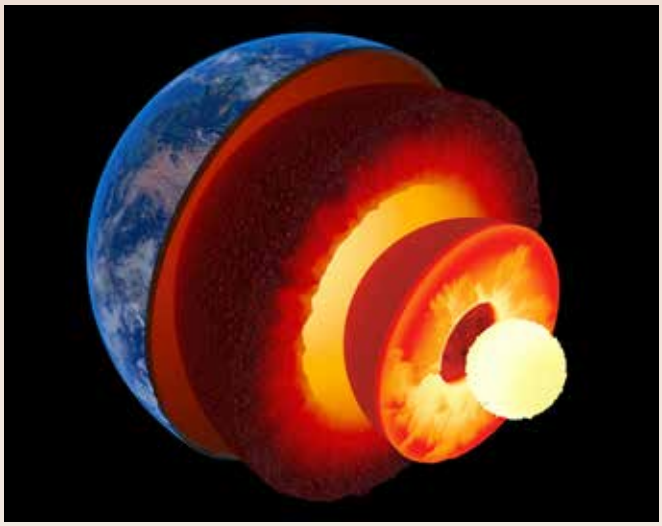
At present many disused quarries are being filled with construction waste. This is a way to rehabilitate old quarries so that the wounds they caused be somewhat healed. The quarries started to recieve construction waste when Magħtab and Qortin landfills stopped accepting such waste. Until that time, Magħtab landfill had been receiving more than one and a half million tons of construction waste, equivalent to one truckload every minute, or 500 trucks for each 8 hour working day. It is important that the waste thrown into quarries be clean so that the water tables be safeguarded against pollution. Over the waste, a layer of soil can be laid out so that the area be dedicated to agriculture or afforestation.

Some old and inactive quarries have been rehabilitated and are now being used for indsutry such as this tarmac batching plant.

1

The diagram on the right shows us the four main layers of which our world is made up.

a. On the same diagram write the name of each layer. Choose from: mantle, crust, inner core and outer core.
b. Fill in the blanks with the given words to complete this paragraph about the structure of the earth.



Our world is made up of four different layers. The outer layer, or earth _____ is made up of _____ rock and its thickness varies from 5 kilometres to _____ . The crust rests on another _____layer called the mantle. The molten rock in the mantle is called _____. The layer beneath the mantle is also molten, but deeper down, where we found the _____ core the rock is solid and reach a temperature of _____.

inner	molten	70 kilometres	
crust	solid	magma	6000°C

c. Our world includes three main component parts: atmosphere, hydrosphere and lithosphere. Write the name of each one in the right place in the table.

The solid crust of the world made up of the continents and ocean beds.	
Gaseous layer which envelopes the world.	
All the water found in the oceans and lakes, in the ice and underground.	

d. Explain why each component mentioned in (c) is necessary for our life.

2

In the world one finds hundreds of different types of rock. However, we can divide all of them into three main categories: igneous, metamorphic and sedimentary.

a. Fill in the table below with the name of the right rock category.

b. Fill in the missing parts of the table on the right.

Rock made of magma emitted from the earth.	
Rock which changed due to high pressure or heat.	
Rock laid down in layers, one on top of the other.	
Rock made up of magma which cooled down underground.	
Rock replete with the shells and remains of sea creatures.	

i. In the first column write the main category of rock.
ii. In the second column mention two examples of each rock category.
iii. In the third column write about the use of each type of rock.
iv. In the last column explain how each type of rock was formed.

Rock category	Two examples	Two uses	Formation
	1. 2. Basalt	1. It becomes fertile soil	1.
	1. 2.	1. 2.	1. Made up of rock particles and marine creatures.
Metamorphic	1. 2.	1. 2.	1.

c. Rock is a raw material, used in many ways. Fill in the table on the right by matching the use with the type of rock.

Rock type	Use of rock
Marble	
Basalt	
Lower Globigerina	
Granite	
Blue Clay	
Slate	
Coal	

3

Look carefully at the map on the right which shows the shape of the Mediterranean millions of years ago, then answer the following questions.

a. Compare the map on the right with a present map of the Mediterranean. Identify the main differences between the two.

b. What caused the change in the shape of the Mediterranean along the years?

c. What happened when great pressure was laid on the sediment which was at the bottom of this sea?

d. State whether this information about the ancient Mediterranean is true or false.

	True	False
In the past the Mediterranean Sea was much larger than today.		
The bottom of the Sea of Tethys was covered with layer upon layer of sediment.		
The Sea of Tethys was so salty that no creature lived in it.		
The Andes Mountains in South America were formed when pressure was laid upon the sediment on Tethys seabed.		
Malta is made up of sediment and creatures which lived in the Sea of Tethys.		
About 7 million years ago the Straits of Gibraltar closed and the sea started to evaporate.		
The Mediterranean Sea remained closed for one thousand years and parts of it dried up.		
When the Straits of Gibraltar opened up again Malta was totally submerged under the sea.		

e. Re-write the wrong sentences in exercise (d) correctly.

f. Is it true that the Alps in Northern Italy were once under the sea? If this is true, how come that they are now so high up?

g. Which is the main proof that all Maltese rock is sedimentary and that it was formed under the sea?

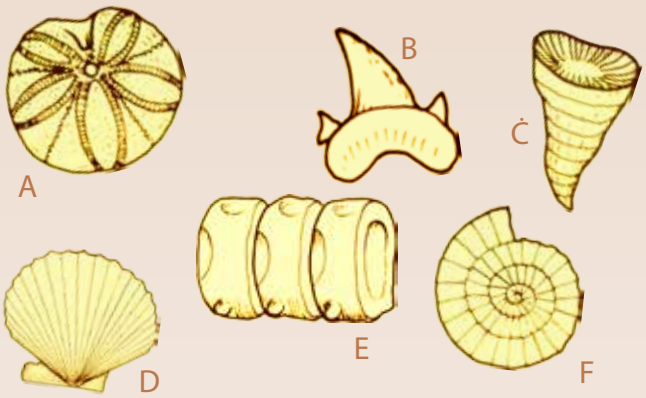
h. Mention some creatures which lived in the Sea of Tethys millions of years ago. Explain why the remains of these creatures are now embedded in Malta's rocks.

i. The Tourism Authority has commissioned you to write a leaflet for both Maltese and tourists who visit Għar Dalam in Birżebbuġa. With the help of pictures and diagrams,

- mention some fossils exhibited in this cave's museum.
- explain how and why these Northern European animals succeeded in migrating to Malta.
- explain what happened to thee animls when Malta became an island again.

j. These are some fossils found in Malta's rocks. Try to identify them. Choose from: shell, coral, shark's tooth, urchin, snail, whale's backbone.

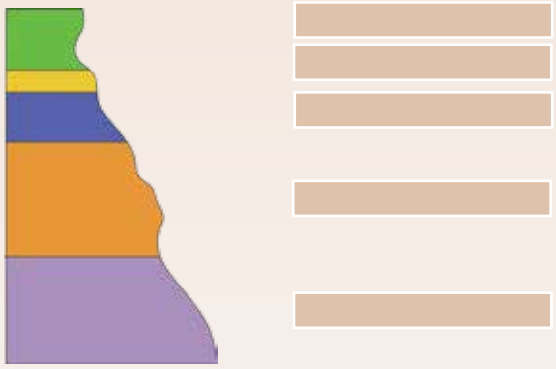
A		D	
B		E	
C		F	



4

Malta is made up of five layers of sedimentary rock which were all formed at the bottom of the Sea of Tethys.

a. In the diagram below write the name of each layer at the right place.



b. Which is the oldest layer of rock in the Maltese Islands? Why do you think so?

c. The layers of rock in Malta have different charcteristics. Try to identify the rock types according to the given description.

Clue	Name of Rock
Orange-coloured sandy rock.	
The oldest type of rock found in the Maltese Islands.	
The last layer of rock to be formed at the bottom of the sea.	
Porous but impermeable rock.	
Forms high cliffs and boulder rock by the sea.	
Is present over 70% of the surface area of the Maltese Islands.	
Impermeable rock upon which water accumulates.	
A layer of rock made up of many remains of coralline algae.	
Forms large areas with hollows, holes, cracks and razor shaped rock.	
Soft rock layer above the blue clay.	
This layer includes three sub-layers.	

5

Look carefully at pictures A, B, C, D and E and then answer these questions.

a. Answer these questions about picture A.
   i. Which type of rock can be seen in picture A?
   ii. Mention some localities in Malta where this rock is at the surface.
   iii. Describe the main characteristics of this type of rock.
   iv. Explain how this rock was formed.

b. Look carefully at picture B and answer the following questions.
   i. What is the rock shown in picture B called?
   ii. Why is this type of rock important in Malta?
   iii. Tick (✔) the correct word/s. The rock layer shown in picture B is

porous		permeable		impermeable	

iv. Mention some places in the Maltese Islands where this rock type is at the surface.

c. Look carefully at picture C and answer the following questions.

i. From which rock type is this boulder derived?
ii. State whether this information about picture C is true or false.

	True	False
This type of rock breaks up easily.		
Large boulders of this layer detach themselves and roll down the cliffs.		
Impermeable rock which does not allow water to percolate.		
Hard rock which is difficult to break.		
This rock was formed at the bottom of the Sea of Tethys.		
Rock layer which has many fossils of marine creatures.		
This layer lies at the surface in a very large expanse of Malta.		

iii. Re-write the mistaken sentences of the above exercise correctly.

d. Look carefully at picture D.

i. What is the rock layer in picture D called?
ii. How many sub-types or members has this layer of rock?
iii. What are the names of the sub-type layers?
iv. What separates one sub-type layer (or member) from the other?
v. Which of these sub-layers is used for building?

6

Over the centuries, Malta was ruled by great empires which all left their mark on the history of the Islands. All used the rock for raw material in order to build megalithic temples, fortifications, palaces, churches, cathedrals and whole towns.

a. Complete this paragraph in order to show how Maltese stone was used through the years. The pictures are there to help you.

When 7,000 years ago the first men came to Malta, they found soft rock at the surface which could be easily excavated and worked. They sculpted these rocks into statuettes and built .....
.....
.....
.....
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.....






b. The building industry in Malta uses two different types of rock, one being somewhat soft and the other being much harder and strong.

i. Mention two rock types in Malta that are used for building.

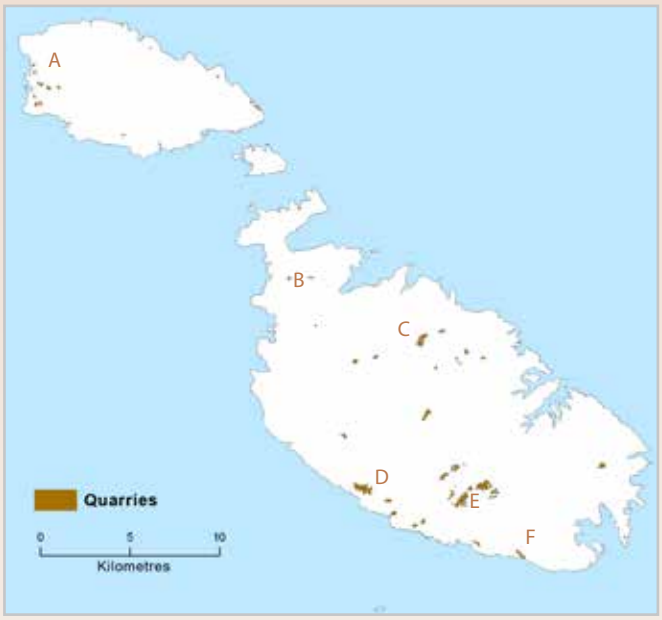
ii. Maltese rock is excavated and used for different purposes. Write the name of the rock used to produce the following

Use of rock	Rock type
Spalls for tarmac	
Fine stone dust for building	
Building stones	
Lime production	
Building sand for plastering	
Sculpture in stone	
Malta 'marble'	
Pavement slabs	
Bricks for building	
Balusters for balconies and parapet walls	
Spalls for concrete and pre-fabricated concrete roof slabs	

iii. Study carefully the map on the right which shows the location of the main quarries of the Maltese Islands.

- Why is quarrying so important and necessary for the economy of Malta?
- Match the geological map in page 79 and then write what type of quarry can be found in the places marked from A to F.

A		D	
B		E	
C		F	



iv. Prepare a presentation about one method of quarrying in Malta. These are some points you might research and write about.

- the location of the quarries
- the type of rock processed there
- the variation in the quality of rock
- the way rock is excavated and cut

7

Read carefully this report published in a local newspaper and then answer the questions.

Residents angered at quarry extension

A number of residents are presenting a petition to the PA after they heard that the neighbouring quarry will be enlarged. 'If this happens, the value of our property will be greatly reduced,' said one of the residents. One other resident stated that they were suffering from noise and dust and that if the quarry is allowed to expand further, it will come nearer and the problem will aggravate. The quarry owner promised that no use of dynamite will be made during excavation and that once the rock is exhausted the place will be turned into a recreation park to be enjoyed by everyone.

The Local Council, as well as environmental groups, are against the extension of the quarry. One of the councillors said that the Council had been asking the authorities to widen the road there since it became traffic-logged due to the quarry works. The quarry owner affirms that quarries provide a vital raw material for the development of Malta's economy.

a. What type of rock is excavated at this quarry?

b. What is this rock used for once it is excavated?

c. Explain how this type of quarry functions.

d. Why are the residents against the expansion of the quarry?

e. What is the local council requesting? Why?

f. Why do you think are the environmental organisations against the extension of the quarry?

g. What is the quarry owner promising in order to minimise the environmental impact?

8

Study carefully the picture on the right.

a. What type of rock is being cut in this quarry?

b. Which sub-type of globigerina limestone provides this stone?

c. What is this rock used for?

d. Make a list of negative impacts which quarrying has on the neighbouring residents, historical sites nearby and the natural landscape.

e. A large area of garrigue will be taken over by a hardstone quarry. What impact can this quarry have on the creatures and ecology of the place?

f. Truckloads of stones and spalls pass through the core of the village on the way to the quarry. What problems can this traffic cause to the residents of this village?

g. In the hardstone quarry rock is excavated by means of explosives. What problems can this cause to a historical place which is only a few kilometres away?

h. Quarry owners plan to turn their quarry, once it is no longer in use, into agricultural land. How can this be done? Do you think this would be a good idea? Why?

9

During the past few years the excavation of rock from Malta's quarries has increased in order to provide for the greater demand. Construction waste increased too.

a. Where do you think should this construction waste be dumped?

b. Some time ago experts met in order to discuss better ways and means to dispose of construction waste. On the right we may see some measures which they thought could be adopted.

i. What would you do with construction waste, throw it away or reuse it?

ii. What can be done with this construction waste?

- Tons of coralline limestone which was excavated while a tunnel was being dug.
- Old roof slabs that were pulled down from an old building.
- Good quality globigerina stone which must be excavated to make way for underground storeys at a hotel.
- Many globigerina chippings that were left when the mason finished his work.

When coralline limestone is excavated at a projected site, it should be taken to a quarry to be crushed into spalls or building sand.
Where large projects are under construction much rock is excavated. This may be best quality globigerina. In this case the rock should be excavated in the shape of building stone to be used for construction.
Stone chipping left over from a construction site should be used to build rubble walls.
Mixed stone may be crushed for chipping bed under the floor tiles.
Stones from demolished buildings should be used for foundations of new buildings, for the restoration of old buildings, or by the fishermen for mooring the floats.
We may dump the waste by the coast and the reclaimed land can be used for residential or for commercial purposes.

Since the sea totally surrounds the Maltese Islands, waves hold a great influence over the coast. Waves pound the coast forcefully during storms. When this happens over a long stretch of time the rocks will break and fall. Sea currents will then transport this material and deposit it in some sheltered bay.

The Weathering of Rock

4

As soon as Malta emerged from the sea the natural elements started to weather the landscape. This happened through agents such as rain, sunshine, wind and waves. This is a continuous process started millions of years ago and which is still active. The shape or topography of the Maltese landscape is the result of the erosion of rock since its first formation.

The landscape is changed by three main processes: erosion (when the rocks break down), transportation (when the material is carried from one place to another) and deposition (when rock, particles and soil accumulates in another place, such as under a scarp). In Malta this process is done by three main agents that are waves, wind and rainwater.

After some heavy rain storm the waters which run through the valleys erode and shape the rock too. This is because the water carries rock particles and stones which scrape the sides and bed of the watercourse. In this way the valleys are deepened and widened. The river carries the material downstream until it loses its strength and will have no more energy to push its load.

To these one must add erosion caused by humans. Through the ages the Maltese people have changed the topography by excavating the rock to build fortifications, roads, dockyards, power stations, airports and other large infrastructural projects. They have excavated deep quarries to supply the building blocks needed for construction and at the same time they have dumped huge amounts of material and concrete in the sea to shape quays and fashion the ports that were all needed for the development of Malta.

The wind is strong enough to hollow and change the shape of rock though not by itself. Wind erosion takes place when it is laden with fine dust or sand. Thus the wind will be able to hollow and even pierce any rock.

This process of wind erosion is very common in the hot deserts. Truck and car drivers in the desert complain about the scratching of the windscreen and body polish of their vehicles whenever they meet sandstorms. This is why rocks in the desert often have fantastic shapes.

Weathering of Rocks

All the rock which covers the land is slowly being, hollowed and weathered until it finally breaks up into small pieces. The main agents which scrape and break down the rock are, among others, rainwater, ice, dew, sea-salt, the heat of the sun as well as plants and animals.

Rock is weathered by means of continuous change of temperature. This physical process occurs when the rock is exposed to alternating heat and cold for a long time. When rock heats up by the high day temperatures its outer crust expands. When the temperature falls during the night the crust contracts a little. This continuous process opens the beds and cracks the rock which will then exfoliates or weathers like an onion skin.

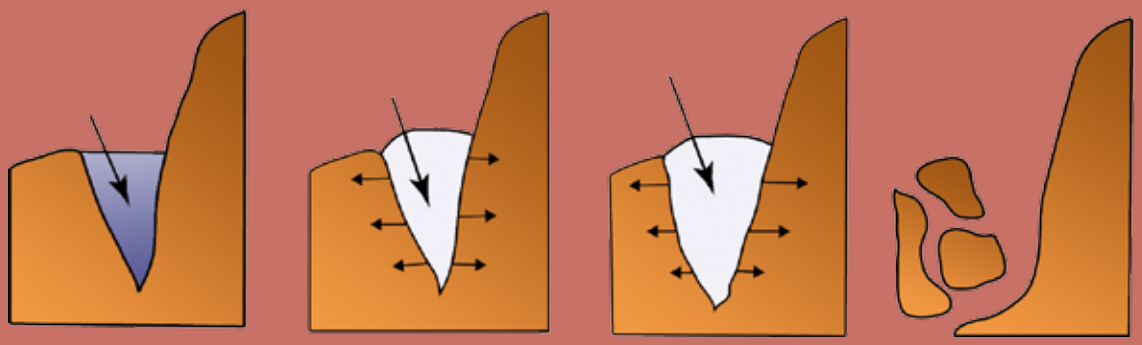
In cold places or on mountains, ice is the major agent that breaks the rock causing it to fall. After rainfall, the water enters the rocks through cracks. By night the water cools down under 0°C, freezes and therefore expands by 9%. Because of this the cracks in the rock widen and become larger. If this process continues for a period of time the rock will crack further until it breaks into big and small pieces that fall down the slopes.

Rock can also be weathered and hollowed by chemical reactions, especially when in contact with rain. When rainwater (H_2O) passes through the air, it collects amounts of carbon dioxide (CO_2) and it turns slightly acidic as carbonic acid (H_2CO_2). This acid weathers the rock, until it is broken down into small pieces.

Apart from physical and chemical causes, there are also biological agents. Biological weathering is a mixture of physical and chemical weathering through the action of animals and plants. During growth, the roots of trees and shrubs enter in between the cracks in the bedrock. In this way the rock will break up further into smaller pieces.

Rainwater includes some acids which weather the rock. This process is clearly visible in the picture below. Chemical processes like these can be seen when balustrades, columns, statues, buildings and single stones are hollowed and turn to dust. High temperatures, air pollution and humidity increase this process especially in such places as Malta where the stone is calcareous. The pointed and razor shaped rocks on the garrigue or on lower coralline limestone coasts were formed by this chemical weathering process.

Frost shattering (Freeze-thaw weathering) in cold climates



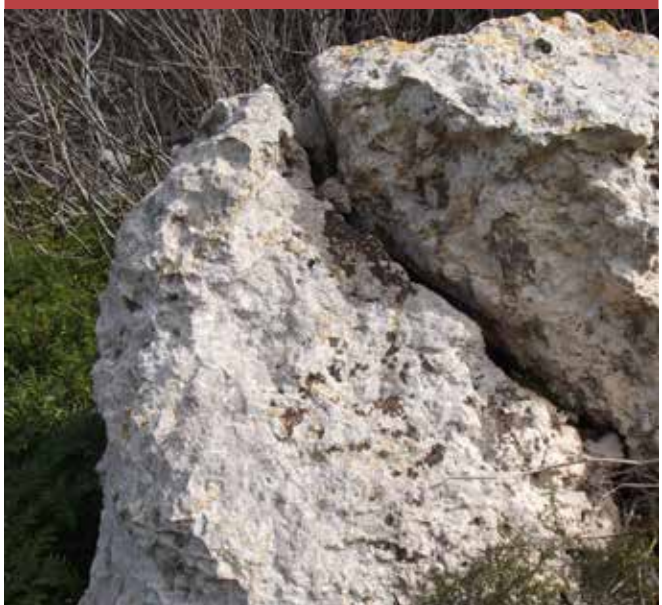
On the mountains rainwater percolates into the cracks.

When temperature falls to less than 0° the water turns to ice.

Ice takes more space than water and the cracks widen due to pressure.

Finally the rock will break up and fall down.

In the above picture we can see how physical, chemical and biological factors work together while breaking up the rock. The continuously changing temperatures during day and night open up small cracks in the rock into which water percolates. Rainwater which is acidic dissolves the rock. In the crack rock particles or dust settles down, though some other will be carried away by rainwater. Seeds which fall into the crack will germinate due to shelter and humidity. The roots of these plants and certain creatures slowly continue the process of weathering of the rock.



There are some animals like mice, ants and wild rabbits which burrow rocks, under rubble walls, trees or shrubs to build their nests. There are also lichens which cause a chemical reaction on the surface of the rock where they live which weakens the rock. Even on the coast there live a large number of creatures such as limpets, urchins and small sea-snails which hollow the rock to find shelter from strong waves.

In the picture above we can see an example of biological weathering. The trees' roots slowly enter cracks in the rock. In time the roots grow larger and thicker. Consequently the roots split up the rock further until it breaks.

These natural processes had a marked effect on the layers of rock in Malta. The rate of erosion of rock by physical, chemical and biological factors varies greatly since each rock layer is not as resistant as any other. Nature's forces act in unison to weather the rock. Later on the broken particles are transported and deposited elsewhere thus completing the process of erosion.

In Malta there are more than 200 different species of lichens. The most common are those in the shape of orange, black, white or grey blobs. While they grow they release acids which weather the crust of rock into fine dust.

The landscape

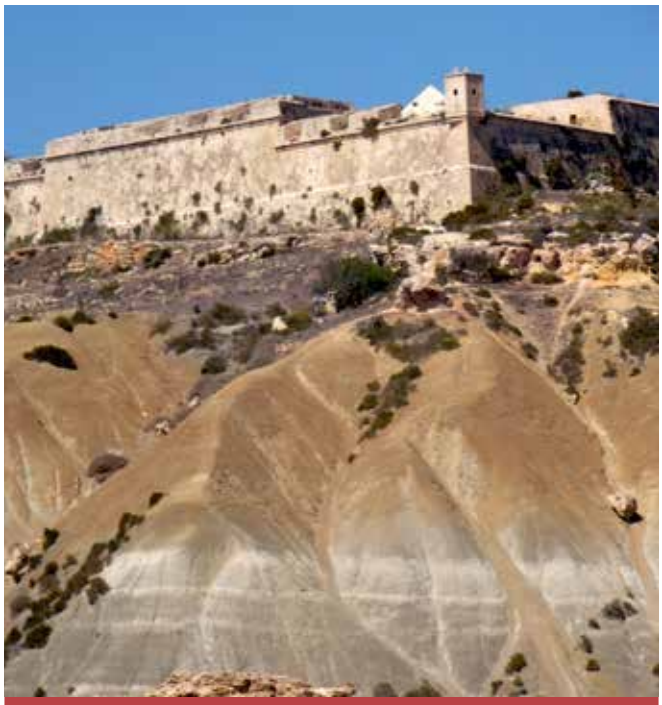
The processes of weathering and erosion work concurrently and slowly change the topography of the Maltese Islands. We must consider that today's landscape including valleys, hills, bays, creeks, plains and cliffs are not permanent but are ever-changing and they will be very different in future. Weathering and erosion do not affect all types of rock in the same manner. Some rock layers are easily broken while others take ages to be weathered.

The hardest rock in Malta is coralline limestone. It is highly resistant to natural elements, however, it too will be weathered and broken in time. In fact this type of rock forms the karstic landscape, characterised by rock that is caved, hollowed, channelled, cracked and razor-shaped. These expanses were shaped by acidic waters which flowed when they were under soil.

The upper coralline limestone lies on two softer layers, greensand and blue clay. It often happens that these two layers are eroded faster than the overlying harder coralline limestone which will therefore be left jutting out in slopes. Due to its own weight and also because there will be little rock left underneath in support, large boulders of upper coralline detach themselves and roll down. This is why we may find a string or row of such boulders in the slopes and cliffs.

Where globigerina limestone outcrops, that is, lies at the surface, it generally forms flat plains since it is much softer than coralline limestone.

The blue clay is the softest layer present in the Maltese Islands. When wet especially after heavy rainfall, it easily slides downslope and covers the underlying globigerina limestone giving the impression that the whole slope is made up of blue clay. Blue clay is also characterised by narrow gullies running vertically. These are created by running rainwater which easily hollows the clay and drives much of it downslope.



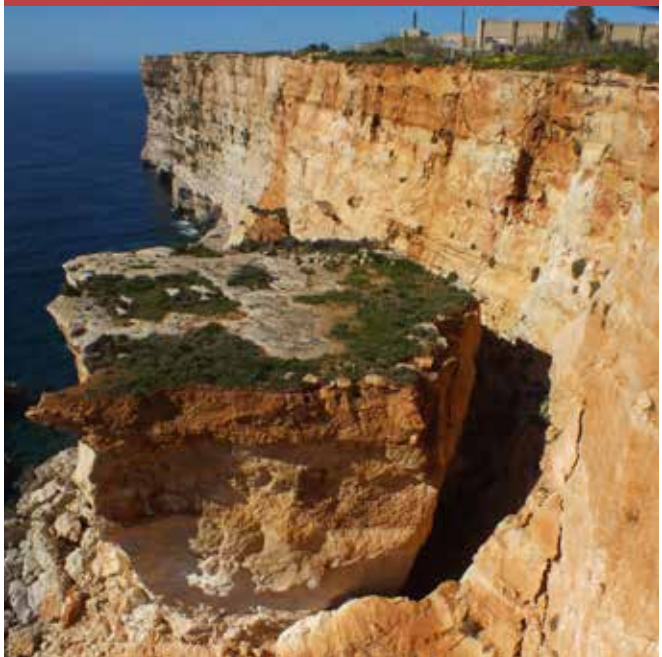
The clay slopes shown in the picture above are situated under Fort Chambrey in Gozo in the area called ix-Xatt l-Aħmar and Ras it-Tafal. When blue clay gets wet it easily slides down and covers the underlying rock. The roots of grasses and plants that grow on the clay slopes slow down this process of erosion.

As can be seen in the three pictures on this page, as well as in the picture in the previous page below, globigerina limestone is weathered, hollowed and bored at a fast rate. In the picture above the blocks of stone have been seriously eroded, the wall has retreated and is in danger of collapse. On globigerina limestone plains one can occasionally come across pedestals such as those seen in the middle picture. These temporary features are topped and protected by a thin layer of harder rock. As a result of salty seaside conditions and other factors, globigerina may form vermiculation with numerous closely packed hollows, similar to a honeycomb.

Erosional processes have played an important part in shaping the landscape. In fact some layers have been totally eroded and eliminated. This happened mostly in the east of Malta where only the globigerina limestone is found lying on a layer of lower coralline limestone. No trace of the other three layers is found.

One must note that chemical erosion processes are increasing. The amount of carbon dioxide and sulphur in the air is increasing due to emissions from factories, power stations and vehicles. This leads to greater concentration of acids in rainwater which hasten erosion of rock.

As can be seen in the picture on the left the hard coralline limestone too will be eroded through the passage of time, forming a characteristic topography. Lower coralline limestone forms high perpendicular cliffs as can be found on the South-western coasts of Malta and Gozo. Coralline limestone can also form large expanses of rocky outcrops with holes, mounds and razor-shaped rock. These were sculpted by acidic rain which broke down and dissolved the calcium carbonate in the rock. Beneath the upper coralline limestone one finds two soft layers, greensand and blue clay. These are eroded at a fast rate and therefore the upper coralline limestone above them will still break up and collapse.



Large Cracks in the Land

The rocks of the Maltese Islands were formed under the sea out of a great amount of silt and sediment. This material was deposited layer upon layer and after millions of years it solidified and became sedimentary rock. In fact a characteristic feature of sedimentary rock is that it is found in overlying layers. Layers are also called strata and therefore sedimentary rock is also stratified. In between layers are found rock beds which witness a change in climate when the layers were forming under the sea. The rock beds indicate the period when one depositional period ended and another began.

The movement of the crust which was active millions of years ago when the rocks of the Maltese Islands were being formed left its mark on the topography of the Islands. Due to massive movements the land began to crack and to collapse. We can observe a series of parallel cracks or faults in the north-west of Malta which cross the islands in a south-west to north-east direction. Along these faults parts of the rock slid past one another. Some were raised to form hills or ridges, while others collapsed to form valleys.

This is how many hills and valleys of Malta were formed, such as Mellieħa Ridge (hill), Wardija Ridge, Pwales Valley and Binġemma Valley. The channels between Malta, Gozo and Comino formed in the same way.

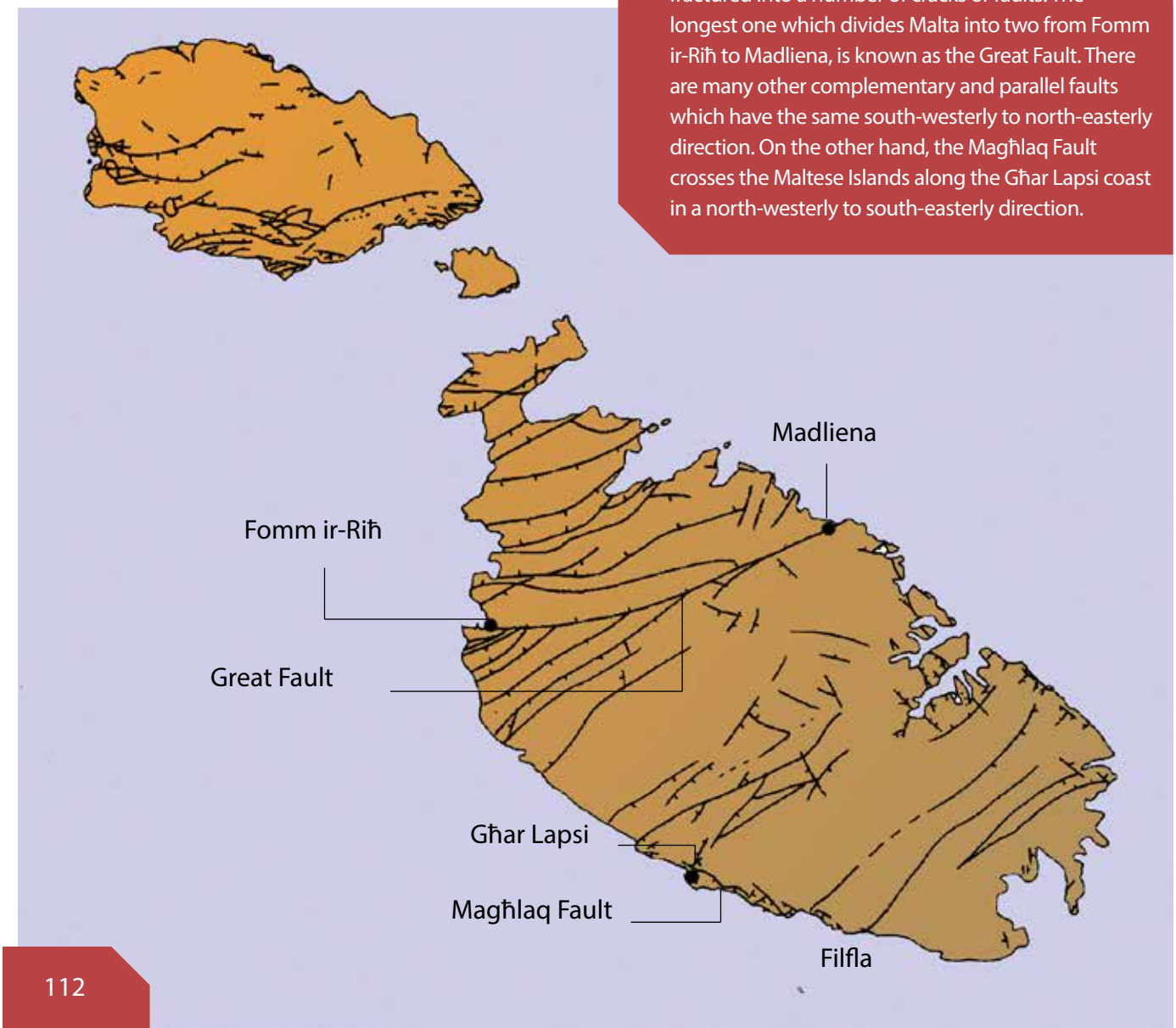
The Victoria Lines were built at the place where the land slid down between 100 and 180 metres. The British built this fortification along the fault which runs from Fomm ir-Riħ to Madliena, so that they could counter any attack which the enemy attempted if the latter landed in one of the large bays of the North.

Another long and deep fault is found at Magħlaq. It is more than 3 kilometres long and stretches along the coast near Għar Lapsi in a north-west to south-east direction.

All the rock which stood between Għar Lapsi and Filfla collapsed by more than 200 metres as a result of considerable movement. These rocks now form the seabed between Malta and Filfla.

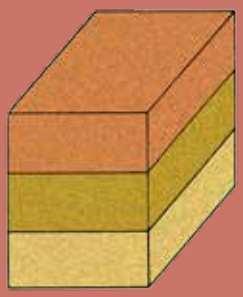
The movement of the crust, erosional forces and the weathering of the rock contributed towards the shaping of the landscape and the formation of the present topography of the Maltese Islands.

As can be seen in the map the Maltese Islands are fractured into a number of cracks or faults. The longest one which divides Malta into two from Fomm ir-Riħ to Madliena, is known as the Great Fault. There are many other complementary and parallel faults which have the same south-westerly to north-easterly direction. On the other hand, the Magħlaq Fault crosses the Maltese Islands along the Għar Lapsi coast in a north-westerly to south-easterly direction.

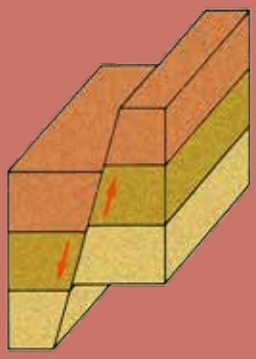


As can be seen in the diagrams on the right, earth movements cracked the land which slid down or faulted with the resultant tension. By a similar process many ridges and valleys were formed in the Maltese islands. Where the land faulted one finds valleys such as Pwales, Għadira and Mistra. Where the land rose one finds hills such as Wardija Ridge, Miżieb Ridge and Mellieħa Ridge.

As can be seen in the picture below taken at Fomm ir-Riħ, we may sometimes find folded layers in Malta. This is also the result of earth movements which crushed, bent and broke layers of rock. Where such movements occurred we find crushed and sloping rock layers rather than straight and horizontal ones.



original landform



landform after faulting and collapse

Along the coast near Għar Lapsi there is a long and deep fault. The land which joined the islet of Filfla to the coast near Wied iż-Żurrieq slid down more than 200 metres and is nowadays submerged. In this manner Filfla was separated and became an island as can be seen in the photograph above. In the picture below we can see a place where the land faulted down uncovering a smooth rock face.

Geologists believe that the massive earth movements occurred when Malta was still submerged. The rock is still faulting due to minor earth movements which are imperceptible for humans.

Underground Caves and Passages

In the Maltese Islands one can find a number of underground caves and passages that were dug up by rainwater over a long period of time. Some of the most famous caves include Għar Dalam and Għar Ħasan in Malta, as well as Ta' Ninu and Ta' Xerri Caves in Gozo.

Often rainwater and spring waters percolate into the rocks. This happens because all the rocks in Malta are porous, having many deep cracks and joints. Rainwater enters these cracks, flows over the layer beds, and forms street-like passages in the rocks. While flowing in these passages, the water widens them and aslo forms large underground caves.

Rain water is acidic since it contains carbon dioxide (CO_2) which can weaken and dissolve limestone. Thus underground passages are formed which later develop into large hidden caves.

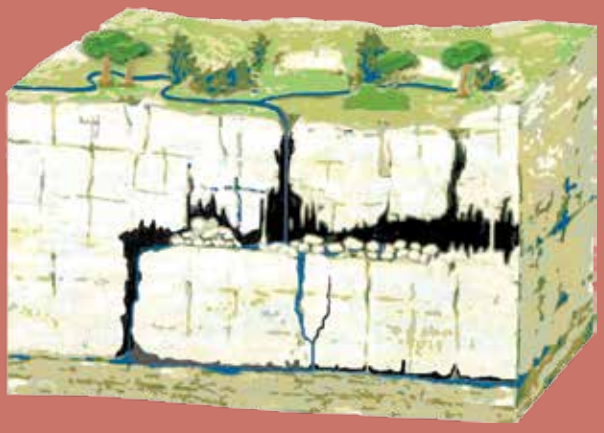
In many caves around the world the acidic waters form spectacular features. The water which slowly drips from the ceiling builds columns called stalactites if hanging from the ceiling and stalagmites if rising from the ground. On its way down acidic water dissolves some of the limestone rocks. When the drop is hanging on the ceiling part of it evaporates and some of it will drop. Each drop leaves a lens of calcium carbonate or lime and in time a cone forms called stalactite.

When the drop falls to the ground it slowly forms a stalagmite. The water which falls from the ceiling dries up leaving a lens of lime, which in time accumulates upward.

These caves can be found all over the world where limestone is present. The picture below shows us the large caves of Castellana, near Bari in Italy where these fantastic shapes were formed through the ages.

Water percolates through the cracks and joints in the rocks.

The water widens the passages on the beds of the layers and caves are formed.



Water drips down the porous layers of rock and the caves are filled with stalagmites, stalactites and pillars.

The diagrams above show clearly how underground caves form. On its way down water dissolves the calcium carbonate and thus opens underground passages. In time these widen into caves of which many remain concealed. The water which drips from the ceiling forms cone-like limestone rocks hanging from the ceiling or rising from the ground.

If water continues to drop the cones hanging to the ceiling will eventually join those rising from the ground. Such columns reaching from the ground to the ceiling are called pillars. The ceiling and sides of the cave get covered in a lens similar to crystal or glass. This is also the remains of calcium carbonate which dissolves water from the rock on its way underground.

There are many caves at Xagħra in Gozo. Ta' Ninu and Ta' Xerri caves are replete with stalactites and stalagmites. As can be clearly seen in the pictures, the stalactites which hang from the ceiling look like thin needles. Others are thicker and have also reached the stalagmites that rose from the ground and formed pillars of many sizes and shapes. Calypso Cave which lies on the cliff of Ramla l-Ħamra, is also adorned with stalactites and stalagmites, however, the entrance to this cave has collapsed and these can no longer be admired. These caves consist of many passages like a labyrinth since they wind under Xagħra and the further one goes the more passages one finds leading to different directions.

The picture below shows one of the most famous caves in Malta, Għar Dalam near Birżebbuġa. Here one finds the remains of hippopotamus, foxes, bears, wolves and elephants which had migrated to Malta to avoid the cold climate of Europe. This was possible since during the ice age the sea level was about 100 metres lower than at present and therefore Malta and Sicily were joined.

Underground caves

Although caves are dark places there still can be found many creatures which have succeeded to adapt to the adverse conditions of these underground passages. Among others one may mention bats which live at Għar Ħasan and other caves. By day these mammals can be seen hanging upside down from the ceiling of caves, while they come out to hunt for insects at sunset. They also hibernate in some sheltered corner of caves during winter to early spring. Some insects adopted dark and humid parts of caves for their habitat. Among these is a woodlouse which lives only in a number of caves in Malta but nowhere else on earth.

Many creatures that have adapted to humid and dark conditions can be found living in caves. For example one can find a kind of woodlouse which is endemic to Malta which has very small eyes and can climb up rocks like limpets. There can also be found a beetle species which thrives on bats' waste as well as white eyeless spiders.

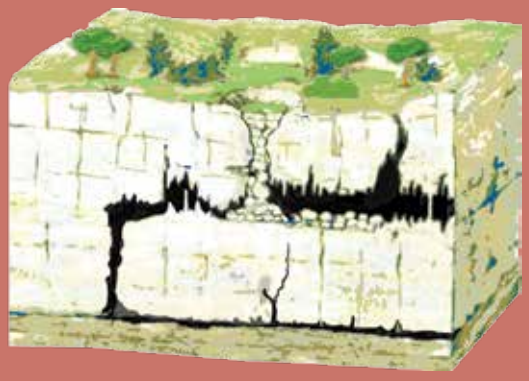
Deep Holes in the Rock

Around Malta many large basin shaped holes can be found. These features called dolines were formed when the ceiling of some large cave collapsed. The most renowned are those at Maqluba in Qrendi as also Dwejra and Qawra in Gozo.

The doline at Maqluba started as a large cave which was formed by rainwater which used to percolate through the rocks and slowly dissolving the calcium carbonate. The rock further weakened as more water passed through. The cave widened and eroded until the ceiling collapsed under its own weight. This left a large oval hole in the ground about 40 metres deep and 91 metres wide.

It is said that the ceiling of the cave which stood in place of Maqluba collapsed during a storm on 24 November 1343. During winter and in rainy years the bottom of Maqluba is filled with water which, however, easily finds its way down through cracks and passages. In this natural environment which is much out of reach many creatures live because they are protected by the shelter provided by the deep hole. Many trees grow around the scarp including carob, laurel, and juniper trees.

On the other hand the dolines found at Dwejra in Gozo formed much earlier when the Maltese Islands were still being formed under the sea. Throughout its geological history, there were periods when Malta was either emerged or submerged. The caves were formed in one of the periods of emergence. Water eroded a system of passages in the rock which in time widened into caves. When the sea level rose again more material accumulated causing the ceiling of these caves to collapse, so that the large rounded holes were formed that are now submerged.



In the above diagrams we can see how the doline at Maqluba was formed. The more water passes through the more calcium carbonate, of which most of the limestone is made, is dissolved. What started as a small pothole will develop into a labyrinth of underground caves and passages which only reach the surface through joints and cracks. The cave will become so large that its ceiling will collapse by its own weight and through tension thus forming a big round hole called a doline.

One of these dolines called tal-Qawra, is shaped like a basin and has a diameter of 400 metres. Nowadays this hole is filled with seawater that comes in from a sea-passage in the cliff called Żerqa cave. The other hole found at Dwejra in Gozo was also separated from the sea by a thin wall. In time this was eroded by the waves. The part which remains forms Fungus Rock. There are other such submerged dolines which attract divers.

In the above picture we can see Għar il-Kbir at Dingli which is made up of eight smaller caves which were inhabited for a long time by a number of families. Nowadays these caves are dispersed around a large hollow which formed in the same way as described above. The people who lived there were shepherds who tended their flocks of sheep and goats. People who live in caves are called troglodytes.

1

a. What is each of the following processes called?

When rocks are broken down.	
When the broken down material is carried from one place to another.	
When the broken down material settles down in another place.	


A


B

b. Study carefully pictures A and B.

i. Explain the process by which the rock is being broken down, transported and deposited in picture A or B.
ii. Name another force of nature, other than A and B, which can also weather and transport rock particles.
iii. Continue this paragraph by using the words given below.

chemical | biological | animals | small | water | weathering | temperature

All the rock at or near the surface is exposed to air, _____, temperature change, plants and animals. These scrape and weather the rock until it breaks down into _____ particles and is carried away. This process is called _____ of rock. This happens in different ways. It can be a physical process due to continuous changes in _____ or as a chemical effect when rock is fragmented into small pieces due to _____ reaction, often with the aid of humidity. Roots of trees and plants, as well as burrowing _____ also help weather the rock. This last process is called _____ weathering.

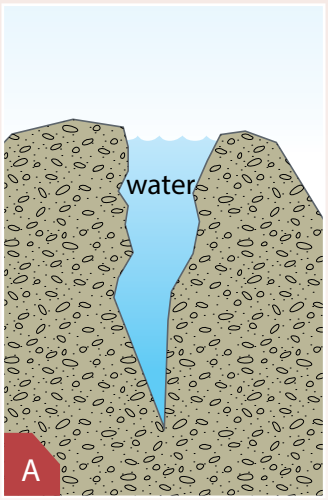
2

a. The sentences below explain how exfoliation or onion skin weathering of rock occurs. Write them in the proper order to show how this process takes place.

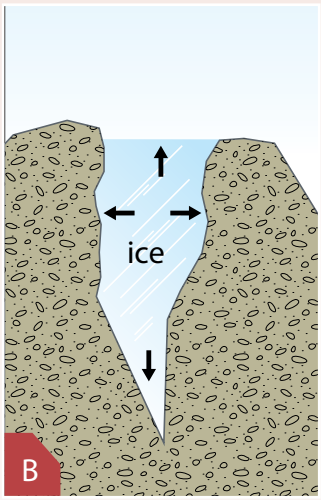
- Rocks contract by night because of the cold.
- The rocks are weakened and cracked.
- Rocks are exposed to daylight heat and expand.
- The rock surface is exfoliated.

b. Look carefully at diagrams A and B which show the physical process of erosion in a cold mountainous place.

i. With the help of the diagrams explain how the erosion of rock occurs in these places.
ii. Draw another diagram in order to complete the process.



A



B

3

The statues shown in page 123 above are being damaged by chemical weathering.

a. Describe the damage that is being done to these statues.
b. Explain why this is happening.
c. Mention some prehistoric or historical monuments that are being damaged in the same way.
d. Complete the table on page123 by filling in the missing parts.

i. In the second column of the table write the name of the process of rock weathering involved. Choose from: exfoliation, chemical weathering, biological weathering or freeze-thaw weathering.

ii. In the third column write the place where such rock weathering occurs.

	Weathering process	Place
Roots of trees that widen cracks in rocks.		
Breaking up of rock by cold when water solidifies into ice.		
Carbon dioxide in water dissolves limestone.		
Rock surface expands by day and contracts by night.		

4

Study carefully the picture on the right then answer these questions.

a. Which type of weathering is breaking down the rock in the picture? Choose from:

chemical weathhering	
biological weathering	
physical weathering	

b. Explain how the rock in the picture is being weathered.
c. Explain how the creatures mention below can weaken the rock and help in its weathering.

- ants
- lichens
- mice
- limpets

d. Go round the school or your town in search of stones that are showing signs of weathering.

i. Take photos of these stones.
ii. Under each photo write:

- the damage which is being done
- the type of weathering process
- the cause of this weathering

iii. Are there any stone-blocks that are weathering at a faster rate than others? Why do you think is this happening?

5

Look carefully at the picture on the right.

a. What type of rock is in the picture? Choose from:

Greensand	
Coralline limestone	
Globigerina limestone	
Blue clay	

b. Is the rock in the picture hard or soft?
c. What is this type of environment called?
d. Describe the landscape that is shown in the picture.
e. Explain briefly how this rock surface developed.

f. Mention some places in the Maltese Islands where one can find the type of environment that is shown in the picture.

6

Look at the photo on the right.

a. Draw a pencil diagram to show the cliff and the boulders as shown in the photo.

b. Label the diagram with the names of the types of rock.

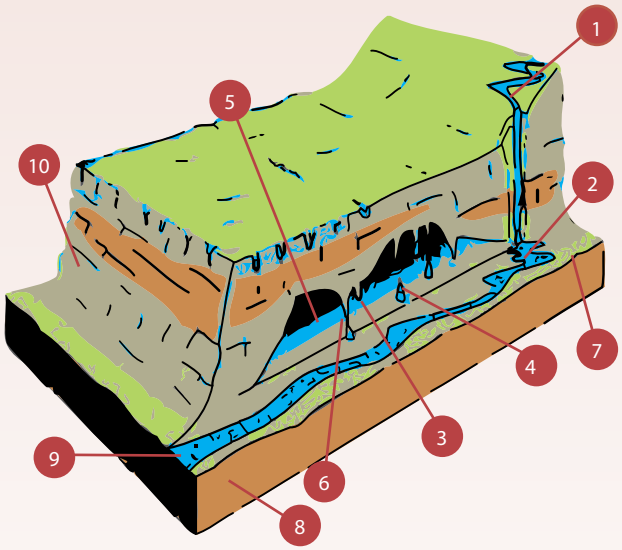
c. The sentences below explain how the large pieces of rock or boulders broke from and rolled down the cliff. Write them in the right order.

- Upper coralline limestone is cracked and broken.
- Upper coralline limestone rock lies upon greensand and blue clay.
- By its own weight upper coralline limestone collapses and huge blocks roll downslope.
- The upper coralline limestone will have no support underneath.
- Greensand and blue clay are soft rocks that are easily eroded.

d. On the diagram you drew mark properly the way that the upper coralline limestone is being weathered.

7

Study carefully the diagram which shows some physical features which can be found underground in limestone areas.



a. Fill in the table by writing the features that can be found according to numbers from 1 to 10. Choose from:

stalagmite | cave | surface river or spring | stalactite | underground river or spring | pillar | bedrock | river resurgence | permeable rock | impermeable rock

b. Name some caves in the Maltese Islands which have features mentioned above.

c. Explain how the physical features marked 3, 5 and 6 in the diagram were formed.

d. Explain how the spring disappeared from the surface in the place marked 1 and then reappeared at number 9.

e. Use websites to research about any famous cave from around the world. Write its location, its size and the physical features which are found in it.

1		6	
2		7	
3		8	
4		9	
5		10	

8

On the map of the Maltese Islands,

a. Mark the location of
   - Fomm ir-Riħ
   - Madliena

b. Draw a straight line to join these two places.

c. By these two places one finds a large scarp in the land. On the map write the name of this scarp or fault.

d. Use the linear scale to measure the length of this fault.

e. In a few sentences explain how this fault, which divides Malta into two parts, was formed.

f. On the map draw one other line to show another similar fault.

9

Look carefully at the diagram on the right.

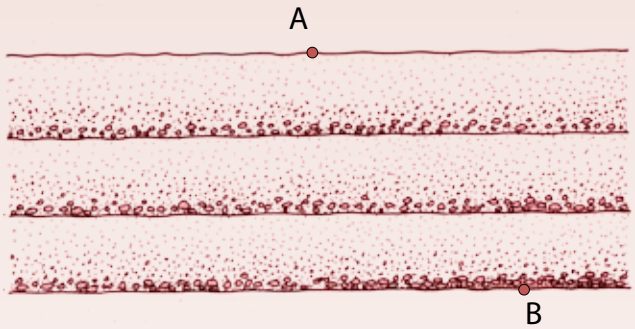
a. What are the rock layers shown in the diagram also called?

b. Why is this sedimentary rock called stratified?

c. In the diagram we can see three different rock layers. What does this indicate?

d. Draw a crack in these layers from A to B.

e. What causes such rock layers to crack and what can happen when this occurs?



f. Draw again the diagram above in order to show what can happen to the rock layers as a result of this deep crack.

10

Look carefully at the photo on the right which shows the Maqluba doline at Qrendi.

a. Choose the correct term. Such features are found in

   1 limestone
   2 igneous rock
   3 impermeable rock

b. With the help of well-labelled diagrams explain how such hole is formed.

c. Mention other places in the Maltese Islands where similar physical features are found.

d. Why do you think are such places ecologically important?

A satellite photo of Vesuvius, one of the volcanoes in the central Mediterranean region. This volcano is very close to Naples and other towns with a total population of 3 million. The last time it erupted was in 1944 but it is famous for destroying Pompeii and Herculaneum in the year 79 AD.

Tectonic Activity

5

After much study and research scientists have a clear view of the way many physical features around us were formed. Many of them are the direct or indirect result of tectonic processes caused by the continuous movements of the earth's crust. The deep faults which are found on the land, seabed, mountains as well as the volcanoes and earthquakes are all the result of these tectonic movements.

Our world is not static but dynamic and is continuously changing. There are more than 600 active volcanoes which erupt from time to time. About 160 strong earthquakes and thousands of other weaker ones occur suddenly each year throughout the world. Some of them cause many deaths and great material damage.

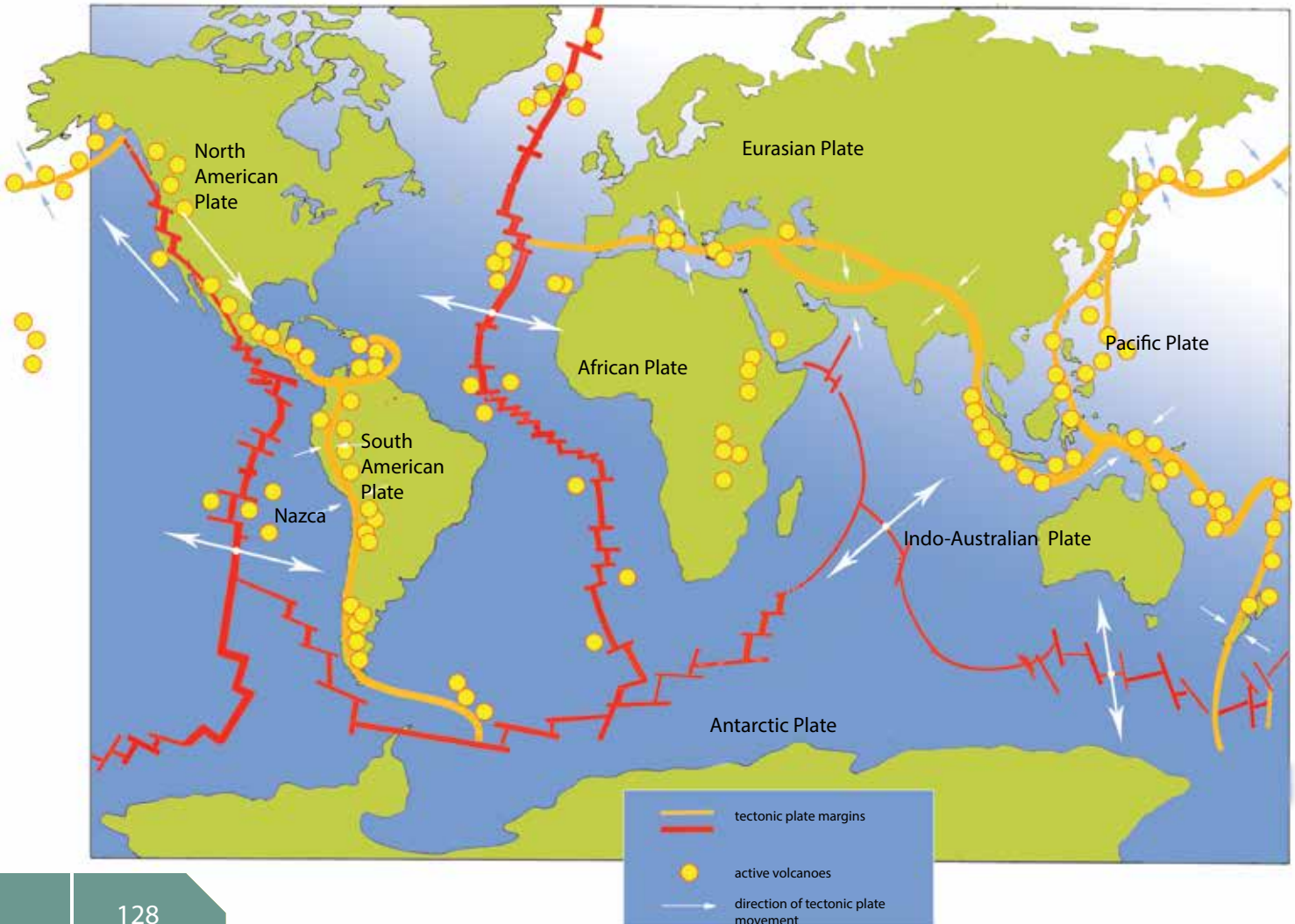
As we can see in the photo below, earthquakes cause most damage when they occur in large cities. In May 2008 a strong tremor hit the province of Sichuan in central China. The earthquake killed thousands of persons and many others were injured or buried under the collapsed buildings.

Earth Movements

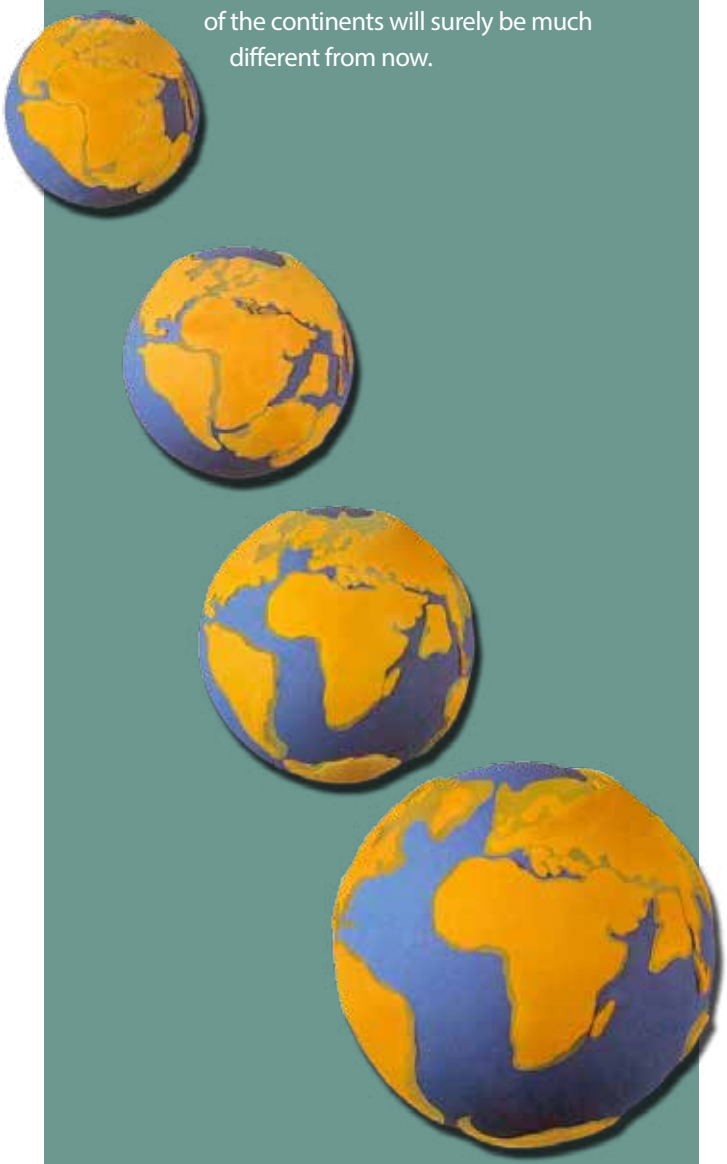
In order to understand how volcanoes and earthquakes occur we must firstly note what is happening under the earth's crust. The world is made up of three main layers. The outer layer is made up of solid rock, only a few kilometres deep. The outer crust of the world can be divided into two types: continental crust and oceanic crust, which together make up the continents and the ocean beds.

These rest on a molten layer of rock called mantle. The molten rock in the mantle is called magma. Deeper inside the earth there is the core with a temperature of 6,000ºC. When this great heat reaches the mantle it creates convectional currents in the magma. These circular currents divide the earth's crust into large parts called tectonic plates. There are seven very large tectonic plates and several other smaller ones. These are resting and floating on the mantle and the great heat emanating from the earth's core is moving them slowly, by just a few millimetres each year.

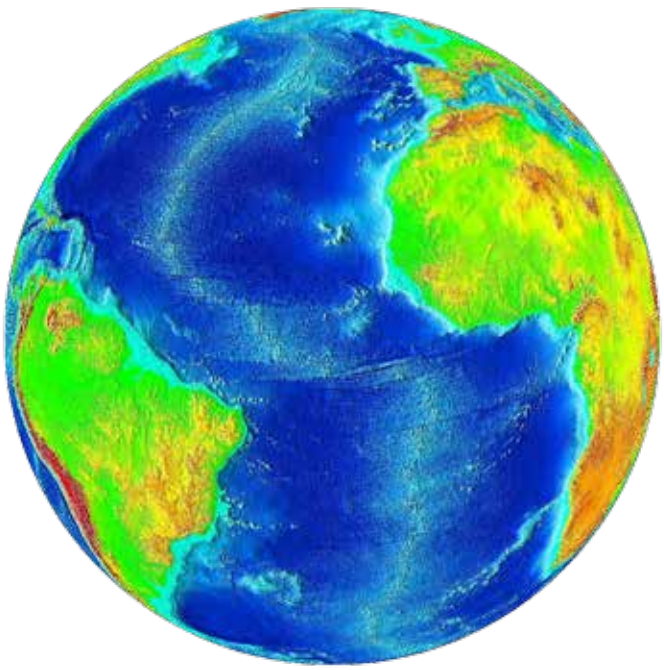
Our world is not static but dynamic and this can be seen in the map below which shows the location of volcanoes and seismic zones that can be suddenly hit by an earthquake. The map also shows the direction of movement of the plates, away or towards each other.



The position of the oceans and continents changed during the geological history of the world since tectonic plates move. The maps below show us how these movements may have happened over a very long period of time. Geologists think that about 300 million years ago the continents were all joined together in one single landmass. They named this enormous continent Pangaea. Due to the convectional currents found underground, Pangaea split up and the Sea of Tethys was formed between what are now Europe and Africa. By the margins of some plates new land was formed and the Atlantic Ocean began to open up. India was detached from Antarctica and moved towards Asia. This movement continued uninterruptedly to shape up the continents as we now know them. But this movement is still at work and millions of years hence the shape and position of the continents will surely be much different from now.

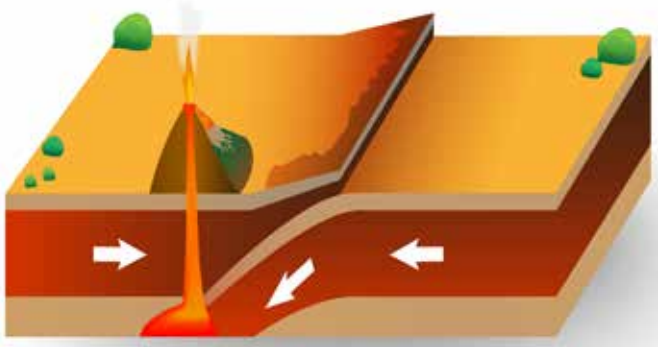


In some areas these plates are moving away from each other while in other regions they are moving towards or past each other. The most active places are the plate margins or boundaries where one plate touches another. Here the land may crack and deep faults may form, or it may rise to form mountains. The plate margins are the places where most volcanoes are situated and where most earthquakes occur.



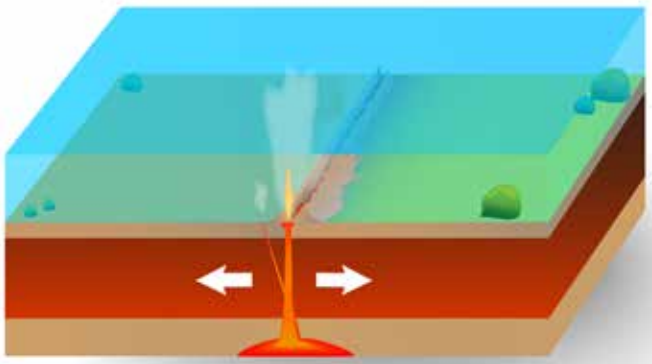
The best example of constructive margin is the Mid-Atlantic Ridge which can be seen in the picture above. Since the plates are moving away from each other the Atlantic Ocean is widening by 3 millimetres each year. This means that every year America is moving further from Europe and Africa. Due to this movement a mountainous ridge has also formed in the ocean bed. The tops of some of these mountains have emerged above sea level and have formed a string of volcanic islands such as the Azores and Iceland.

Plate margins can be divided into four types according to the relative direction of their movement. When two plates move towards each other a destructive margin is formed and one of them is subducted and destroyed under the other. Earthquakes and destructive volcanoes are very common in these margins. For example this process is taking place on the western coast of South America.



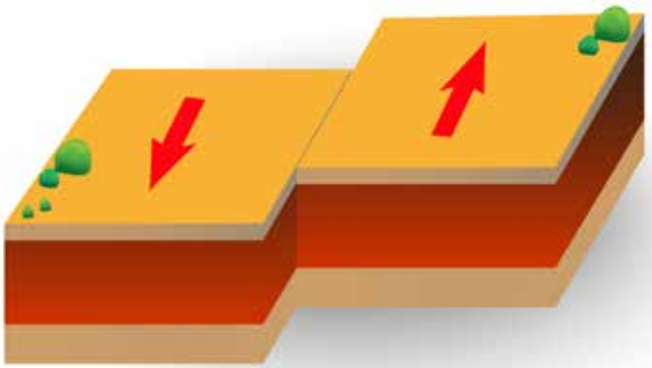
When two plates move and push towards each other, the world's crust may also bend and be crushed under the resultant great pressure. In such collision margins mountain ranges such as the Alps in Europe and the Himalayas in Asia are formed.

In other places the plate margins are moving away from each other. These are called constructive margins and are mostly found under the oceans. The empty space which is formed is taken by magma and lava. When these cool and solidify they build a narrow stretch of high land or ridge all along the plate margin.



In conservative margins the tectonic plates are moving past each other. This type of movement causes strong earthquakes such as the one which hit the state of California in 1906 when more than 26,000 homes were destroyed and 1,000 people perished. In fact more than 40,000 tremors are registered every year in this seismic zone, especially along the conservative margin.

The Himalaya Mountains in the north of India lie on a collision margin. Here the rock was pushed and pressed to form the highest mountains in the world. These places are also subject to strong tremors. In 1993 more than 10,000 people died and 150,000 other remained homeless when a strong earthquake hit central India.



Volcanic Activity

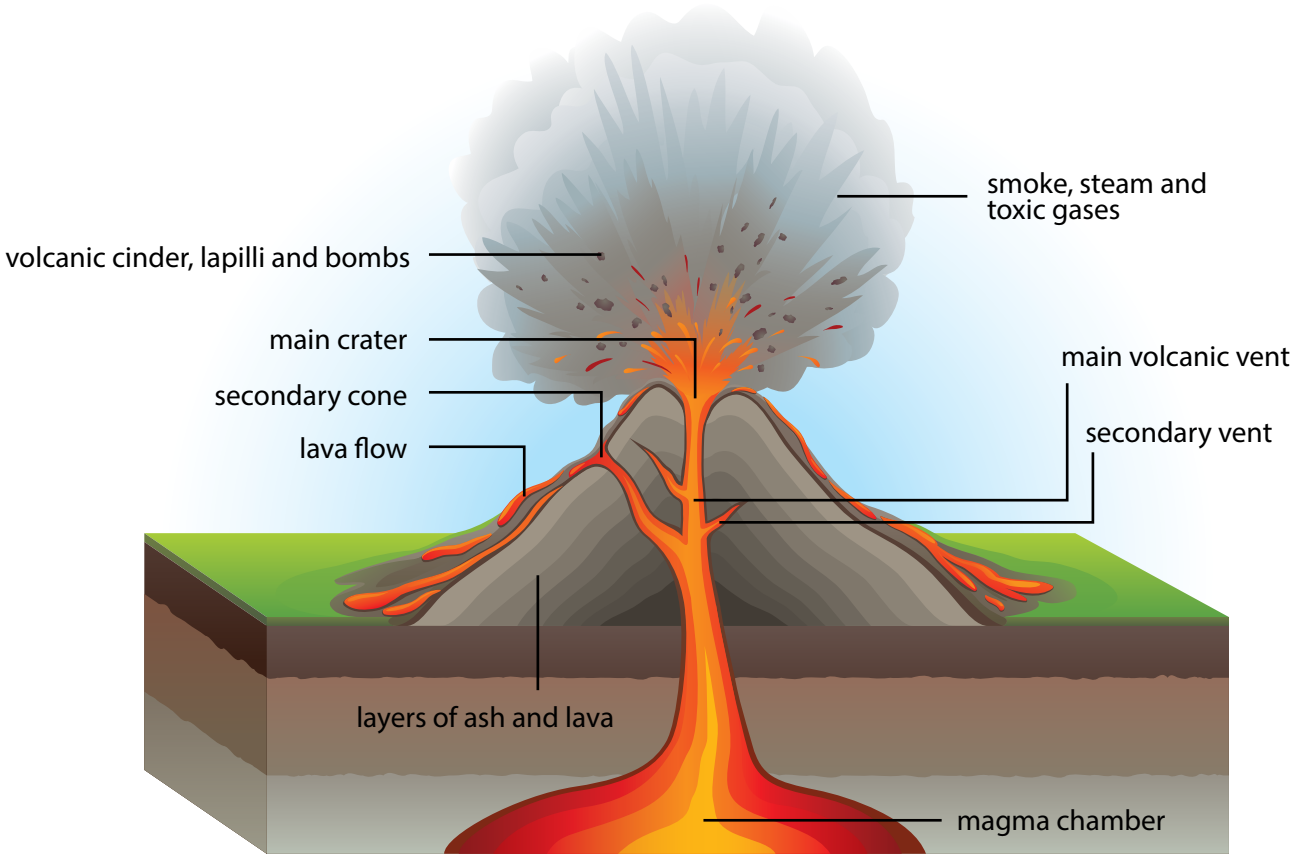
Volcanic eruptions are among the most spectacular and destructive natural events. They alter the environment, the weather as well as global climate. And they also affect millions of people who live close by. Boiling and bubbly lava is emitted from deep cracks in the rock and covers the land. Ash, smoke, steam and poisonous gases fill the air and pieces of rock are ejected from the crater causing serious damage wherever they fall.

A volcanic eruption occurs whenever molten rock in the mantle, called magma, finds its way to the surface. When magma cools, it solidifies and becomes volcanic rock made of lava.

Whenever a volcano erupts, much lava and ash are emitted. These will deposit in layers and in time a mountain is formed. If the magma emitted from the volcano is semi-molten, it cools and solidifies quickly, thus forming a steep-sloped volcano as can be seen in the photo below.

On the other hand, if the lava that is emitted is very molten, it travels much further until it cools and solidifies, forming a more gently-sloped volcano. In other places the lava comes out of deep fissures in the rock. The molten rock goes out slowly from deep

When a volcano erupts, magma comes out of the vent with great force. The magma is stored in a chamber in the earth's crust or in the upper mantle. Secondary vents are formed when the magma finds its way through fissures by the side of the volcano. Whenever volcanoes erupt great quantities of volcanic cinder and ash, lava, smoke, and poisonous gases are ejected. The lava and ash fall close by and slowly build the volcanic mountain. Smoke and other particles can travel for thousands of kilometres in the atmosphere. The lava may flow quickly down the slopes of the volcano forming a lava flow which can destroy whatever lies in its path as can be seen in the photos on the left.



fissures and thus a large area of flat land all made out of lava forms.

Volcanoes are usually only active for some time, maybe for some weeks or months only. In between eruptions they may be dormant or inactive even for hundreds of years. In this inactive period the main vent and crater of the volcano will be plugged by the solidified magma. When pressure builds up yet again, a great explosion take place to free the vent and crater for the lava to flow. A volcano is said to be extinct if it shows no sign of activity in two or three thousand years. There were cases when a volcano long thought to be extinct suddenly erupted causing great destruction.

There are over six hundred active volcanoes in the world. In Indonesia alone there are more than one hundred. Indonesia lies on a destructive margin between the Eurasian and the Indo-Australian plate. Some of the volcanoes found there are well known and erupt occasionally, among which Tambora, Merapi and Krakatoa.

Volcanoes

A look at the map in page 128 shows us that volcanoes are situated on tectonic margins, on constructive margins where the plates are moving away from each other. Because of this, magma which is emitted, builds up volcanic islands as happens in the middle of the Atlantic Ocean. This is how the Azores, Canary Islands and other volcanoes in Iceland were formed. The majority of volcanoes are found on destructive margins where oceanic crust is subducted and dissolved in the mantle under the continental crust. Cotopaxi and Paracutin volcanoes in Mexico are situated on a destructive plate margin.

The greatest concentration of volcanic activity is situated around the Pacific Ocean, called the ring of fire. This zone starts in Japan and runs south to the Philippines and Indonesia, on to the east of the Pacific where many volcanoes are found on the western coast of America. Finally in the north one finds strings of volcanic islands including the Aleutians and the Kurils which complete the series of volcanoes between North America and Japan.

Seismic Activity

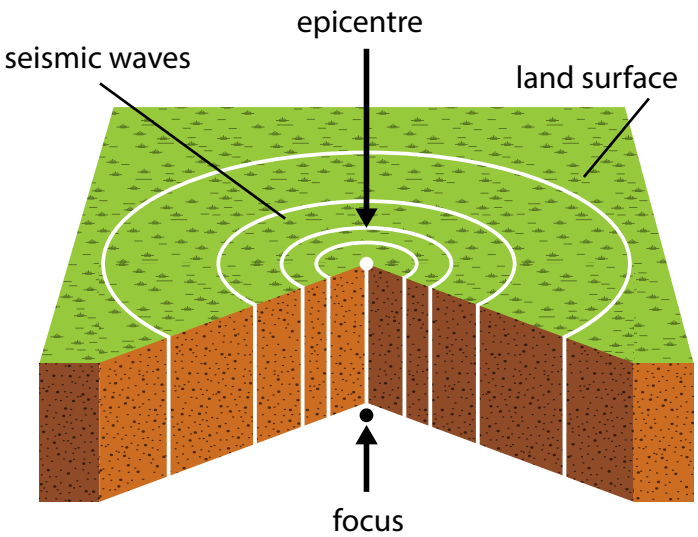
While volcanic activity is the final result of pressure by magma which would have accumulated for a long time in the earth, earthquakes are sudden hazard events. Every earthquake is the result of strong movements that occur in the earth's crust which cause tremors or seismic waves. The effects of a strong earthquake may be disastrous: the ground shakes and many buildings collapse causing many people to be buried under the rubble and lose their lives.

In a single year more than 80,000 earthquakes occur. Fortunately only a few take place in inhabited areas or are strong enough to cause serious damage. The strength and effects of an earthquake are measured with special instruments.

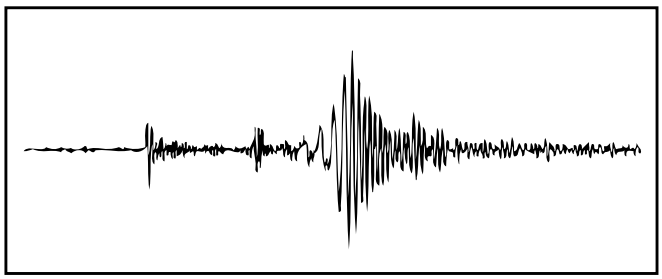
By the Richter scale we would know the strength of the tremor and the seismic waves which travel underground during an earthquake. These tremors are measured by an instrument called seismograph. This draws a seismic trace of the earthquake called seismogram. The Richter scale measures from grade 1 to 10. Each grade is 10 times stronger than the previous grade. This in fact means that an earthquake which measures grade 6 on the Richter scale is 10 times more powerful than one of grade 5, and 100 times stronger than one of grade 4. Generally an earthquake which marks grade 7 on the Richter scale will cause considerable damage. This is what happened in Pakistan in October 2005, when an earthquake of grade 7.6 on the Richter scale killed 73,000 people and left millions other homeless.

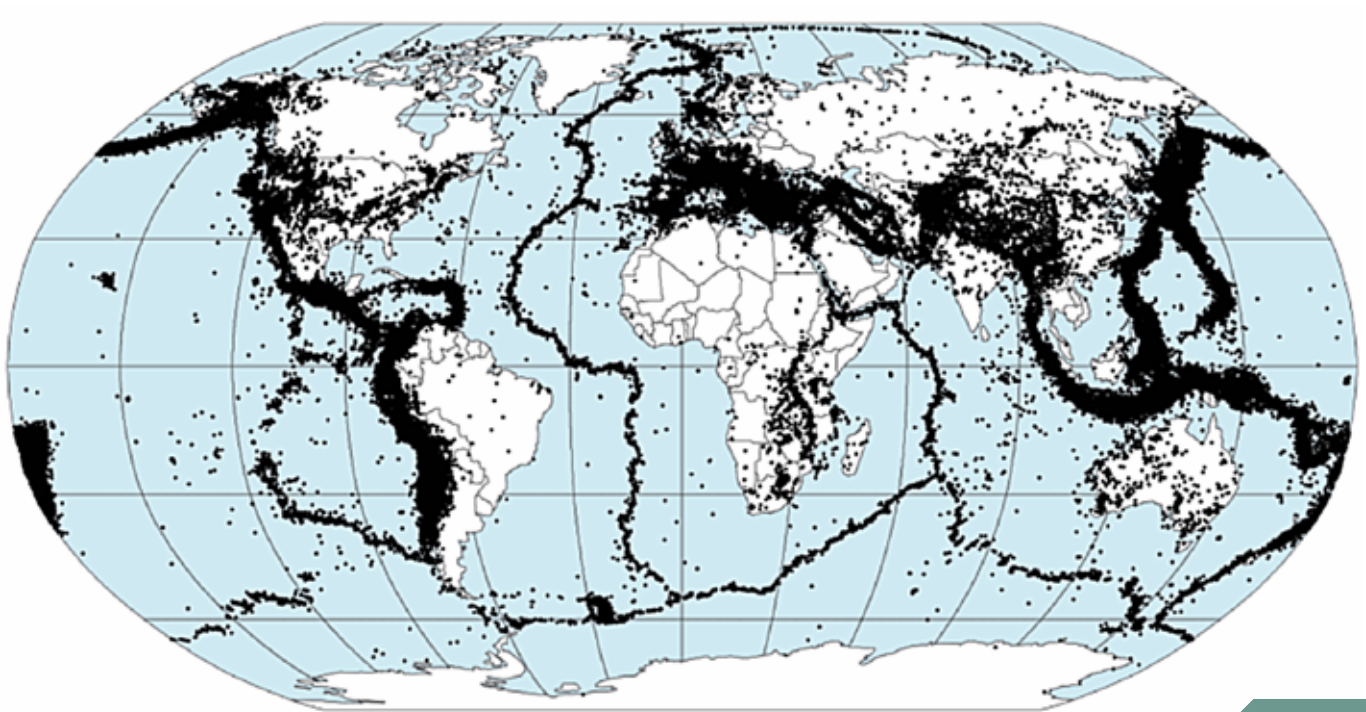
Another system used is the Mercalli scale, which measures earthquake in grades from 1 to12 according to the destructive impact of the tremor. The measure is only finalised after that all the damage in the area of the earthquake is carefully assessed.

In the diagram below we can see the point where the earthquake originated, the exact place where the land faulted underground. This is called the focus of the earthquake which is generally 5 to 15 kilometres below the surface. The epicentre is the place where the earthquake reaches the surface, where it is most strongly felt and where most damage is done. The further the seismic waves travel from the epicentre, the weaker will be the tremor and the lower the damage. Seismic waves are emanated from the focus in all directions and are measured by a seismograph which traces a seismogram. This shows the time and intensity of the tremor.



The world map shows us places hit by an earthquake since 1960. We can notice that the epicentre of most earthquakes lie on or near tectonic plates (see map in page 128). Many earthquakes happen on constructive margins where the plates are moving away from each other as happens in the middle of the Atlantic Ocean. Stronger earthquakes occur in collision and destructive margins, especially where one plate is sliding down and being destroyed under another. Many earthquakes that occur in Indonesia, India, Japan, China and Peru are the result of such processes. Places like California, which lies over a conservative margin, are also affected by strong earthquakes. Hundreds of small tremors are registered in this American state every day, but occasionally the earthquake is so strong that it leaves behind total destruction such as in 1906, 1989 and 1993.





A tremor on the seabed or near the coast may cause high waves called tsunami. These waves advance at a fast speed sometimes reaching 800 kilometres per hour. On reaching the coast they inundate with great energy and destroy whatever lies in their course. This is what happened on 26 December 2004 when an earthquake measuring 8.9 on Richter scale hit the Indian Ocean just off the coast of Indonesian island of Sumatra. The tremors on the seabed caused 15-metres high waves which destroyed whatever stood on many coasts of Indonesia, India, Sri Lanka, Thailand and many other countries (see photo on the right). More than 300,000 people perished and about 1.7 million lost their homes. Entire cities were lost during this tsunami.

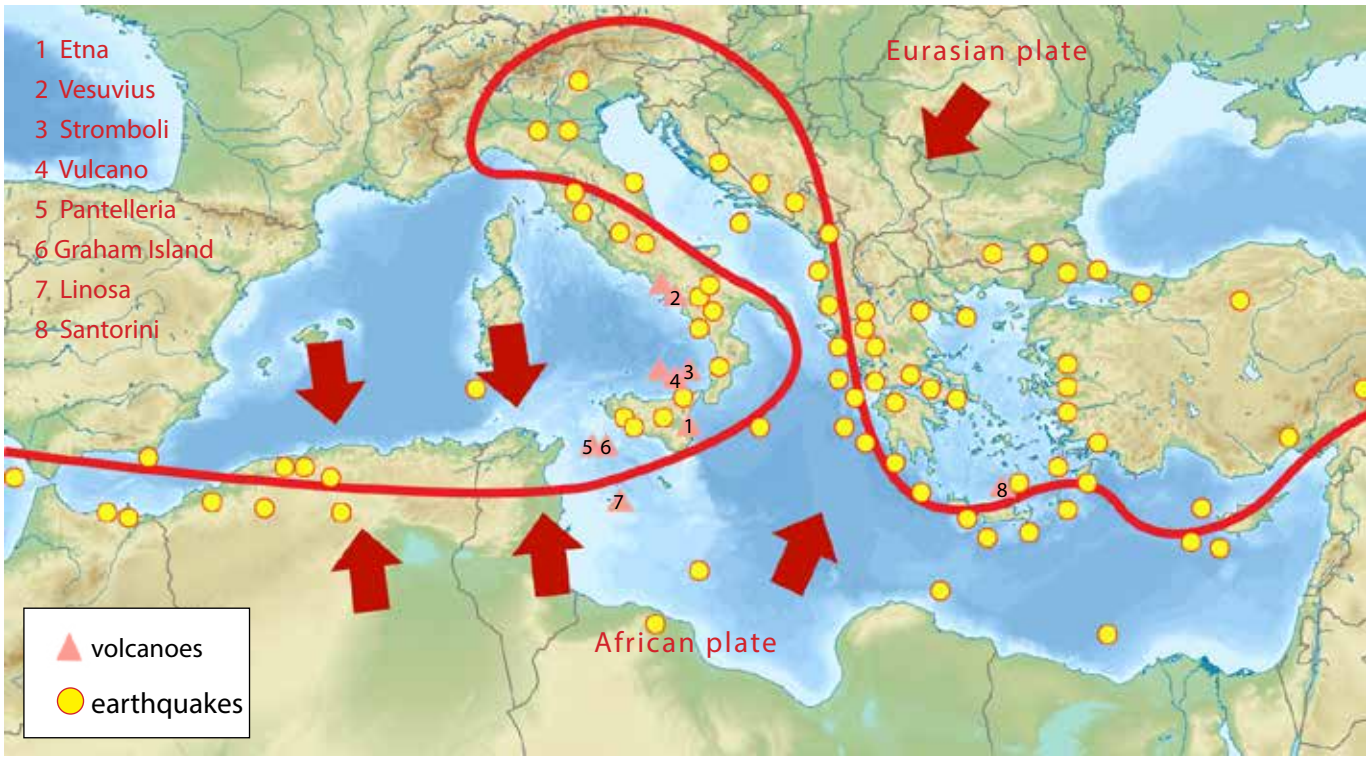
On 11 March 2011 an earthquake that measured 8.9 on Richter scale caused a tsunami which killed 18,000 people in Japan. The high wave entered the coast and reached places 10 kilometres inland, destroying whatever was in its course. The nuclear power station of Fukushima, which lies in the earthquake zone, suffered large damage and millions of people had to be evacuated for fear of a nuclear explosion and consequent radioactive emissions.

Tectonic Activity in the Mediterranean

The entire Mediterranean region is subject to strong earthquakes and volcanic activity. This instability is caused by the tectonic margins which cross the Mediterranean Sea right through the middle. In fact the map on page 140 shows us clearly the margin between the Eurasian and the African plates. The margin between the plates starts at the Azores in the Atlantic Ocean and passes through the Straits of Gibraltar, the North African countries, Sicily, Greece, Turkey and goes on the Caspian Sea in Asia.

Since millions of years ago, these two plates have been moving and pressing towards each other. This collision margin is leading to great instability and has also caused disastrous earthquakes in the past years. The map shows us the epicentres of earthquakes which hit the Mediterranean. Among the worst hit countries one finds Greece, Italy, Turkey, Algeria and Morocco.

One of the most catastrophic earthquakes occurred in 1755 at Lisbon in Portugal. Since at that time seismographs had not



been invented as yet, one can only give a rough estimate of the intensity of the earthquake. In fact seismographers suggest that the earthquake measured 9 on the Richter scale having its epicentre in the Atlantic Ocean, about 200 kilometres west of the city. In this earthquake 50,000 people died and 85% of the buildings were destroyed.

On the other hand, volcanic activity is concentrated in the centre of the Mediterranean although some small volcanic islands are also found in the Aegean Sea. In Sicily there is Etna the highest and most active volcano which has been erupting since 500,000 years. Near Naples in Italy one finds Vesuvius, another active volcano, famous for having destroyed the city of Pompeii in the year 79 AD. Moreover, near Sicily are situated the volcanic islands of Stromboli, Vulcano, Lipari, Pantelleria and Linosa. There are also dormant or extinct volcanoes, such as Marsili on the seabed of the Tyrrhenian Sea, which at the moment do not show any sign of volcanic activity, though they can become active again at any moment.

Etna is the highest volcano in Europe. It is an active volcano, having erupted twenty-one times in 2013. Hot lava flows from its numerous craters. Bombs, lapilli, and cinder are emitted, as well as black ash which is carried by the wind.

During the Lisbon earthquake of 1755 there were three tremors lasting three minutes. The land cracked and faulted in many parts of the city. The terrified survivors went out of their homes. Those who were near the coast watched the sea retreat quite a long way from shore. Forty minutes after the earthquake a massive tsunami destroyed whatever had been spared by the tremors on the coast. A fire developed in the higher parts of town which were unaffected by the tsunami and it took seven days to extinguish. Other towns in Portugal suffered substantial damage too. The earthquake was felt in many places in Europe and also in North Africa. The earth also shock in Finland, 3,600 kiolmetres away from the epicentre. People also died in Morocco and Spain. 20-metre high waves hit the coasts of North Africa as well as Martinique and Barbados in the Caribbean on the other side of the Atlantic.

Italy and Turkey are occasionally hit by strong earthquakes. In 1980 more than 3,000 people died and 10,000 others were injured during a 6.9 Richter scale earthquake. The epicentre was in the hillside town of Conza in the Irpinia region, 80 kilometres south-east of Naples. As can be seen in the photo above the damage was immense. In 1976 another earthquake hit Friuli in Northern Italy that left more than 70,000 homeless.

In the photo we can see Etna erupting between October 2001 and January 2003. When the volcano erupted copious amounts of ash and cinder were emitted from the three craters and were carried by the wind as far away as Libya, 600 kilometres distant. The lava that flowed along its slopes damaged souvenir shops, hotels and restaurants, and also destroyed tourist facilities in the area. Whenever the volcano erupted the million people living in Catania and the surrounding towns are faced with hardship and problems.

In August 1999 a 7.5 Richter scale earthquake struck at the village of Derince, near Izmit in Turkey. About 40,000 people died under the rubble and another 42,000 lost their homes. (See the photo below.) This earthquake also caused high waves in the Sea of Marmara, submerged many places along the coast and also affected Istanbul at the entrance to the Black Sea.

In April 2009 a 6.9 Richter scale earthquake hit the Abruzzo region in Italy. 300 people perished and 65,000 had to abandon their homes. The tremors caused damage in the infrastructure of the place especially in the historical centre of the city of Aquila. Private homes, public buildings, shops and historical monuments were heavily damaged. The disaster negatively affected the economy of the region since many shops were lost and economic activities were much reduced.

Tectonic Activity in the Maltese Islands

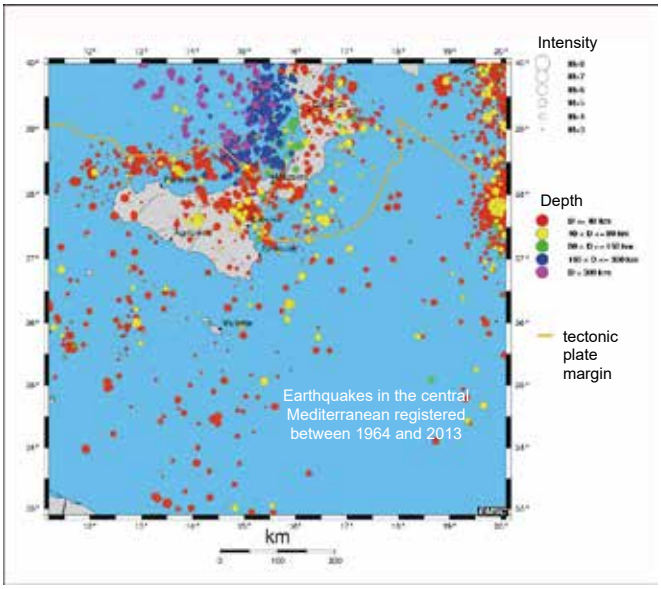
As we have already noticed the Mediterranean Sea was much larger than today. This large sea took its present shape since tectonic forces pushed it and bent it. Like a vice, the Eurasian and African plates crushed the sediment which lay on the bed of the Sea of Tethys pushing the land upward. This tectonic activity also led to the rise of mountain chains all around the Mediterranean.

This tectonic movement continued for a long time pressing the rock at the seabed, bending and breaking it. In some areas the seabed fell further down and in some other places it emerged above sea level. In some places the land cracked and formed volcanoes. By this process the Maltese Islands also surfaced.

The Maltese Islands are composed of sedimentary rock only and there is no trace of volcanic rock. However, the Maltese Islands are surrounded by many volcanoes, some of which are active. To the north of Malta are situated Etna in Sicily, the volcanic islands of Stromboli and Lipari as well as Vesuvius near Naples. To the north-west one finds Pantelleria and the submerged volcano at Graham Shoal. The volcanic island of Linosa is quite near to the west of Malta. The earthquakes which are felt in this region, usually before some volcanic eruption, can affect Malta slightly.

Malta is about 200 kilometres distant from the collision margin between the Eurasian and African plates. Due to this distance Malta does not suffer from strong earthquakes. Notwithstanding this, if a Richter scale grade 7 or stronger earthquake strikes in South Sicily, it can cause much damage in Malta too. This is what happened on 11 January 1693 when an earthquake hit Catania and other nearby towns killing 100,000 people. In Malta this tremor was strongly felt. Although no one lost his life, much damage was caused to houses and churches. The front part of Mdina including the cathedral, as well as the old city of Gozo, both suffered irreparable damage. The cathedral had to be demolished and rebuilt. The people were terrified also since the tremor was followed by a tsunami. The sea retreated at first but then rushed onshore with considerable force.

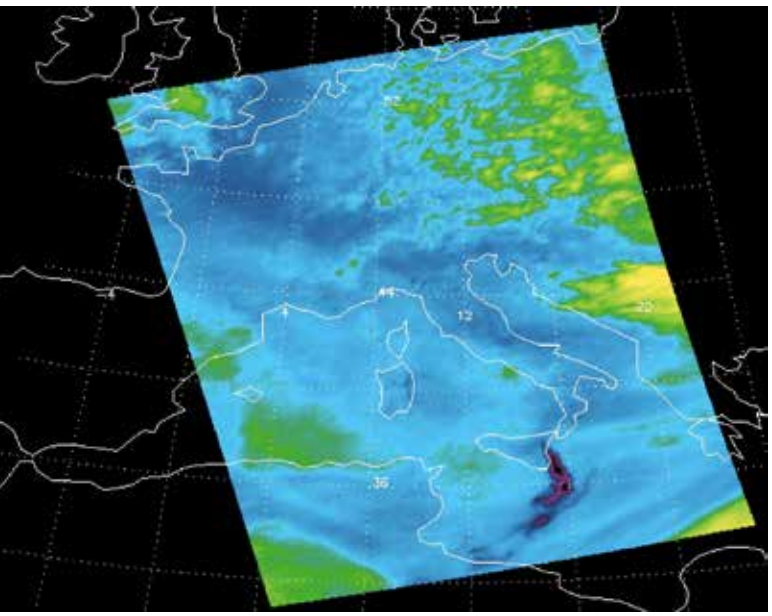
In 1886 a series of tremors were felt. These caused some damage in Valletta, Rabat and Mdina. Along the years many earthquakes in Sicily were also felt in Malta. In certain cases the people went out in panic, especially when



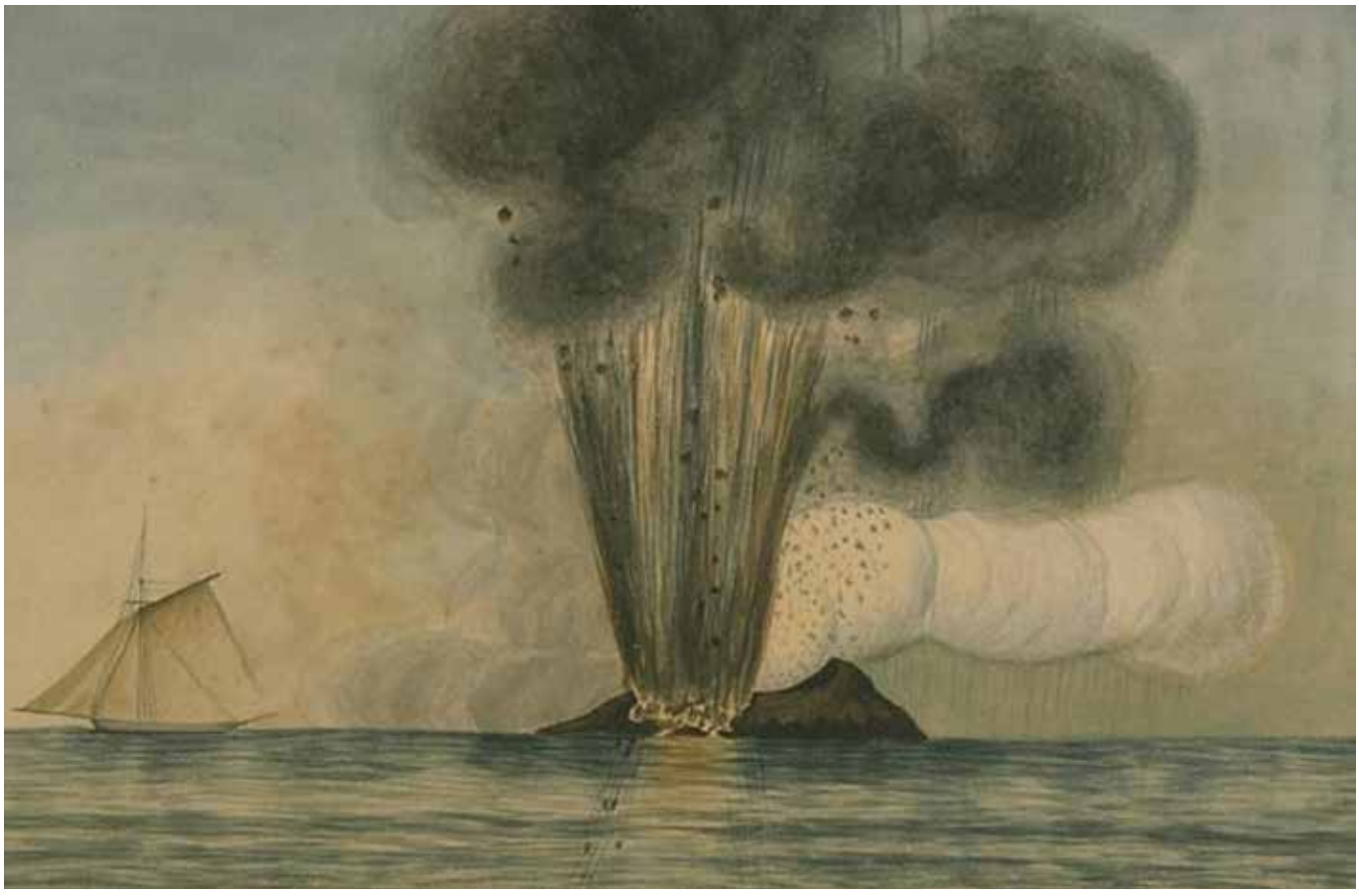
buildings were damaged or collapsed, however, there never were casualties.

Mediterranean undersea earthquakes were also sometimes felt in Malta. In 1972 a grade 4.5 Richter scale earthquake with its epicentre about 50 kilometres to the south-west of Malta was clearly felt. The ground shook for a few seconds and thousands of people went out of their homes in fright.

As often happened in the past earthquakes that strike Sicily or Sothern Italy (photo below) can cause some damage in Malta.



There are a number of volcanoes in central Mediterranean. Some of them have been dormant for a long time, while others are very active. In the satellite photo we can see an ash cloud being emitted from Etna and moving southwards towards Malta. Fine, grey, volcanic ash can be harmful to human health especially to those who suffer from asthma. At that same time there were large amounts of sulphur dioxide in the air. (See map on the left.) Any substantial amounts of such gas may have grave consequences on people who suffer from heart or respiratory disease.



The volcanic island of Graham or Ferdinandea as it is called in Italian is situated about 40 kilometres to the south of western Sicily. This is one of many islets close to Malta that occasionally show signs of volcanic activity. Most are submerged, however, on occasions, a few have emerged above sea level. For example, Fredinandea emerged and sank again five times, and presently its crater is only 8 metres below sea level. In 1831 Ferdinandea emitted gases, ash and lapilli for more than a month and slowly emerged as a new island in the central Mediterranean. Above is a painting of this island with a height of 56 metres above sea level and a circumference of 5 kilometres. Within six months the island was totally eroded by the strong waves and all of it ended up under the sea. In 1863 the island showed new signs of activity and in fact emerged for some days.

More recently in 2000 a series of tremors were registered near the island of Ferdinandea and many thought that it was going to re-emerge from the sea. However, the volcano did not erupt and Ferdinandea is still a shoal or reef 8 metres below sea level.

In the photos of this page we can see deep cracks or fissures in the rock. Strong tectonic forces which affected the Mediterranean have cracked and faulted the rock. Therefore the Maltese Islands are divided into a number of faults, the most conspicuous being that which divides Malta into two known as the Great Fault. Here the land slid down for more than 100 metres and formed a step-like fault from Fomm ir-Riħ in the south-west to Madliena in the north-east of Malta.

The tectonic movement of the central Mediterranean has caused the Maltese Islands to emerge or rise in the south-west and to subside or tilt down in the north-east. This is the reason why the highest places lie in the south-west, that is Dingli Cliffs in Malta and

ta' Ċenċ Cliffs in Gozo. On the other hand the same movement has submerged the north-east coast forming the shoreline at Sliema, Baħar iċ-Ċagħaq and Marsalforn.

Tectonic Hazards

Every year, thousands of tremors are reported from around the world. Fortunately only a few are strong enough to cause social, economic or environmental loss.

Earthquakes cause most damage when they strike large cities. Strong earthquakes of grade 7 or over on the Richter scale leave many dead, injured or homeless people. For example, this is what happened in 2005 in Pakistan when a grade 7.6 Richter scale earthquake killed 76,000 people and left millions of others homeless. Strong tremors can also cause extensive fires that burn for days on end. This is what happened in 1995 in Japan when an earthquake struck with such intensity that underground gas pipes and many electrical

When an earthquake occurs deep cracks open in the ground. These damage or destroy roads, bridges, dams and other structures. In the 1995 Japan earthquake many people lost their lives when a flyover collapsed. During the same earthquake, a number of fast trains were derailed and many people lost their lives or were injured.

In the days following an earthquake, the people suffer for lack of food, water, sleep and other necessities. Many people are injured and others remain homeless. Disease will strike due to lack of hygiene and uninterred bodies. Often, foreign governments and international voluntary organisations immediately send doctors and workers who can help the victims. Other material necessities such as blankets, camps, food, water and medicine are also dispatched.

cables were broken. Where this happened many wooden houses caught fire and were reduced to cinder.

Negative impacts

In earthquake-prone areas engineers are planning structures that are anti-seismic, that is resistant to tremors. Purposely manufactured springs are placed in the foundations of high buildings in order to absorb the impact of the movement of the ground. Such measures together with exercise, preparation and planning help in reducing the damage caused by earthquakes.

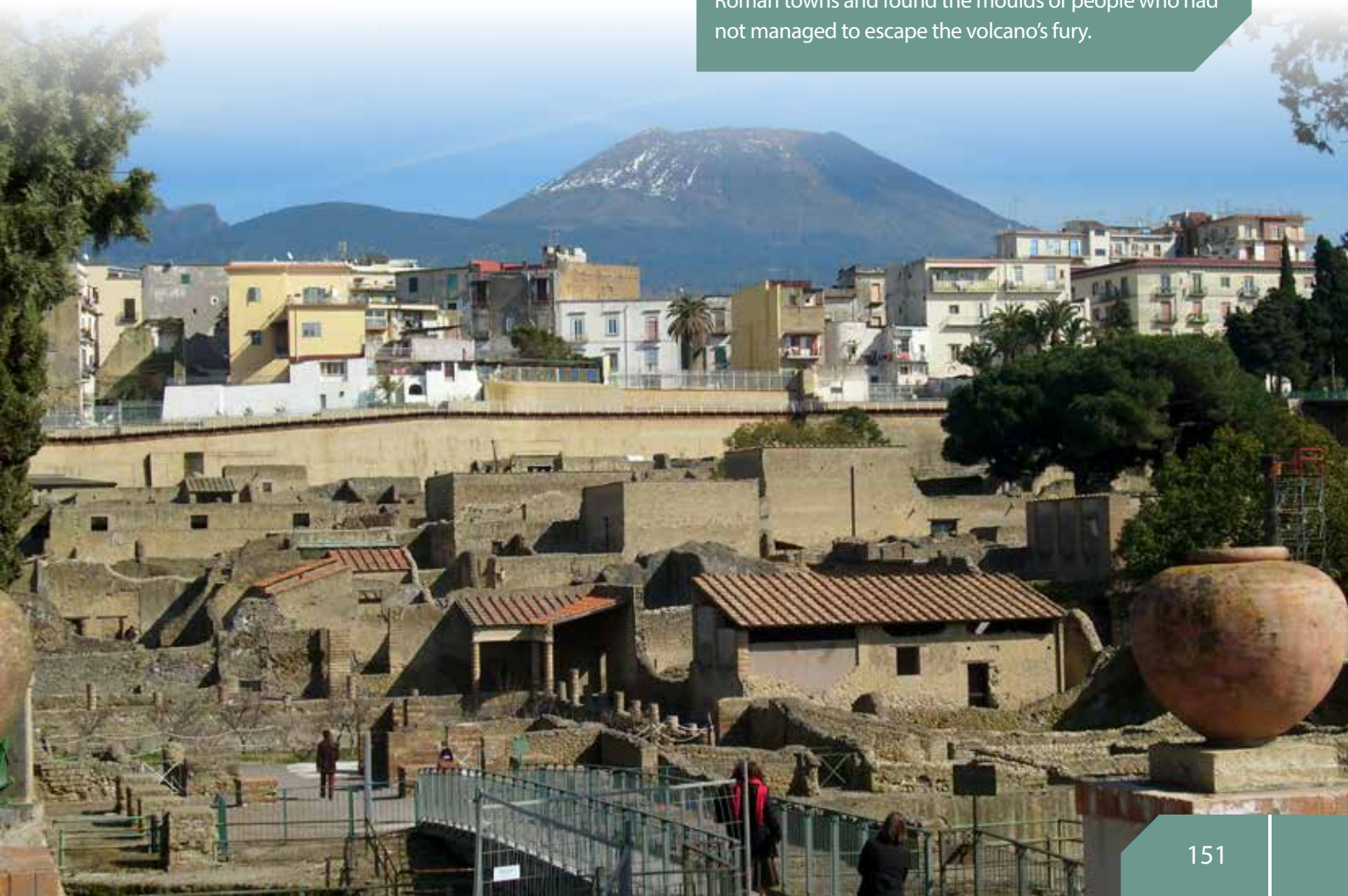
When volcanoes erupt suddenly they too leave much destruction. The impact will be devastating on the people and the close environment. More than 200,000 people fell victim to volcanic eruptions in the past 500 years. An estimated 580 people perish each year.

In the above photo we can see lava coming out of mount Etna in Sicily. This lava forms a flow which moves down the slope of the volcanic mountain. Rarely do these flows leave victims but they bury and burn whatever lies in their path. In 1983 millions of tons of lava destroyed hotels, restaurants, sports facilities, houses and fields. The lava was flowing at 15 kilometres per hour and it was feared that it might destroy three hamlets that were in its course. To avert this, retaining walls were built and canals were dug. These successfully diverted the course of the lava flow away from inhabited areas.

In 1985 the volcano Nevado del Ruiz in Colombia erupted suddenly. The hot gases and ash which were emitted from the volcano melted the ice and altogether flowed rapidly downslope. This mud and ash avalanche buried the city of Armero where more than 23,000 people perished. In 1902 a pyroclastic cloud composed of volcanic ash, dust, steam and gases, having a temperature of over 500°C, destroyed the city of St Pierre in Martinique Island. Out of 30,000 inhabitants, only two were saved.

Usually when a volcanic eruption occurs, a considerable amount of ash and dust are emitted with great force. The finer particles of this dust will be floating and buoyant in the air for years and greatly affect global climate. The 1991 eruption of volcano Piñatubo in the Philippines lowered considerably the global temperatures of the following year.

The eruption of Vesuvius in 79 AD is famous for the destruction of the two Roman cities when they were buried under many tons of ash. The cities of Pompeii and Herculaneum were destroyed by a pyroclastic cloud of gas, ash and burning lapilli and bombs with a temperature of over 240°C. The cities were totally buried and were forgotten until they were accidentally discovered in the 18th century. Archaeologists excavated these buried Roman towns and found the moulds of people who had not managed to escape the volcano's fury.



The NASA sateelite image on the right shows the volcano of Santorini in the Aegean Sea. This volcano erupted with a cataclysm in the year 1650 BC causing the collapse and submergence of part of the island. Only three islands, the largest of which is called Thira, remain out of the original large volcano. Enormous amounts of volcanic ash and cinder were dispersed all over the eastern Mediterranean. Moreover 150-metre high waves crashed on the northern coasts of Crete, more than 100 kilometres away. Scholars believe that this eruption caused the demise of Cretan (Minoan) civilisation.

Beneficial Effects of Tectonic Activity

Notwithstanding the dangers and destruction which volcanic places may bring, they still attract people. Some large cities are situated close to volcanoes which have destroyed the lives of thousands of people in the past. For example three million people live in Naples and the nearby cities around Vesuvius.

However, one has to keep in mind that nowadays we are in a better position to forecast an eruption thanks to modern apparatus like satellites, lasers and computers. Moreover many active volcanoes are regularly visited by volcanologists who take samples of the rock and gases which can indicate whether volcanic activity is on the increase. By such measures, the neighbours of any volcano may be advised in time to evacuate the area.

Volcanic activity may also be beneficial. When lava and ash are weathered and broken, they form fertile soil that is ideal for the cultivation of coffee, citrus trees and vines. Precious stones, metals and minerals are the result of volcanic activity. Such metals include copper, manganese, silver, gold, lead, uranium and titanium.

Ash which is thrown out during volcanic eruptions includes minerals that fertilise soil. Hence the countryside surrounding volcanoes is usually ideal for cultivation. This is the main reason why so many people live in such dangerous places. The farmers in the environs of Etna (in the picture below) cultivate olives, fruit, vines, walnuts and a variety of other crops.

Positive impacts

In a number of countries like New Zealand, the United States and Iceland, the boiling water which emanates from volcanic ground supplies the houses with warm water and heating.

Volcanic areas are attractive for tourists. Every year millions of people visit Vesuvius, Pompeii, Etna lava flows and the geysers in Iceland and Yellowstone in the United States.

Forty-four percent of energy generated in Iceland comes from geothermal sources. When water meets the shallow hot rocks it turns to steam. As can be seen in the photo below, the steam with a temperature of 300°C moves the turbines and generates electricity. This is an efficient source of energy since it does not harm the environment while producing electricity and is also renewable.

This hot water is used to heat homes. Moreover fifty-eight percent of homes in Reykjavik, the capital city, are supplied with hot water. Hot water from geothermal plants is also used to warm greenhouses, swimming pools and lakes. (See picture on the left.) In fact, whatever the weather, swimming is a favourite sport in Iceland.

In volcanic areas, water that percolates into the rock through fissures quickly heats up and becomes steam that is then ejected as can be seen in the photo below. These spouts which regularly emit steam or hot water are called geysers. Such geysers are found in active zones as in the United States, New Zealand and Iceland.

In certain volcanic areas the earth's crust is somewhat thin and therefore the magma is quite shallow. Surface water, or water that percolates into the cracks, heats up and turns into thermal steam at 50°C. Since this water contains high quantities of minerals and medicinal properties, it can relieve pain. In fact such places are popular with tourists. This water can be mixed with mud or soil and the hot mud pools thus formed will also have thermal qualities. In the photo above we can see tourists covered in this thermal mud.

Positive impacts

In the photo on the right we can see a mine of volcanic rock on the Greek island of Gyali in the Aegean Sea. Here mining is carried on for a type of rock known as pumice stone. This is a very light rock for its size, so much so that it floats on water. Pumice is used in the construction industry, mostly in the production of light-weight concrete. Since it has a rough surface it is also used in the production of tooth-paste and in beauty parlours for the cleansing of the skin.

Other volcanic rock such as lava is cut in the shape of slabs for paving roads and for other uses.

Throughout the year volcanic landscapes offer a variety of attractions for the tourist. Among other attractions, they offer snow-covered mountain-tops, sandy beaches, thermal steam and geysers. Below we can see a beach of dark sand on a volcanic island. This was formed out of lava which cooled quickly and broke into very small pieces and later sand upon meeting the sea.

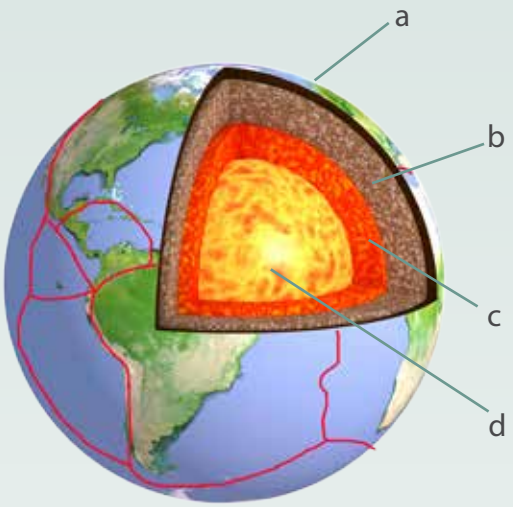
1

Study carefully the diagram on the right which shows the internal structure of the earth.

a. In the table below write the name of each layer.

a		c	
b		d	

b. Which layer is made up of solid rock about 5 to 70 kilometres thick?
c. Which layer has the highest temperature?
d. Which layer contains molten rock or magma?
e. In which layer are there slow circular currents?
f. On the diagram draw these circular currents in the right place.
g. Due to these convectional currents the crust of the earth is broken into large blocks. What are these blocks called?
h. On the diagram mark and name one of these blocks.



i. What are the red lines on the diagram called? Choose from:
   1 mountains
   2 rivers
   3 tectonic plate margins or boundaries
   4 roads

h. Explain why tectonic plates move.

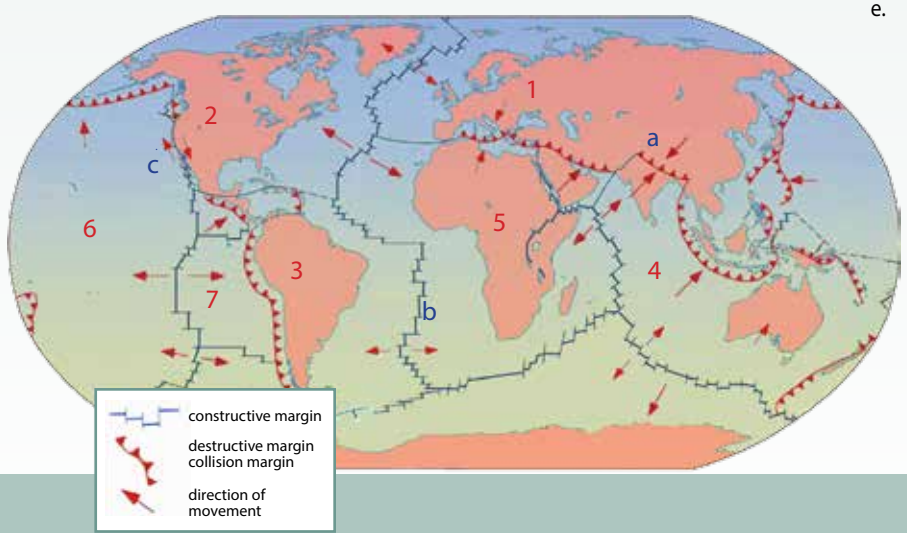
2

Look carefully at the map below which shows tectonic plate margins and their direction of movement.

a. Name the tectonic plates marked by numbers 1, 2, 3, 4, 5, 6 and 7.
b. Name the two tectonic plates which meet in the Mediterranean Sea.
c. With the help of the map fill in the blanks of this paragraph.

France lies on the _____ plate. Two other countries on the same plate are _____ and _____. There is a _____ margin where the African plate meets the Eurasian one. Brazil is on the _____ plate. We find a _____ margin where this plate meets the Nazca plate. This is how the _____ mountain chain was formed all along the western coast of South America. Between the North American plate and the Eurasian plate one finds a _____ margin since here the two plates are moving _____ from each other. In this way the _____ Ocean is opening and widening.

d. What is happening to the tectonic plates in the places marked by letters A, B and C?



e. Some countries are more earthquake-prone than others. Mark the countries that are at high risk of being struck by strong earthquakes.

Nigeria	
England	
Japan	
Central Australia	
Greece	
New Zealand	

3

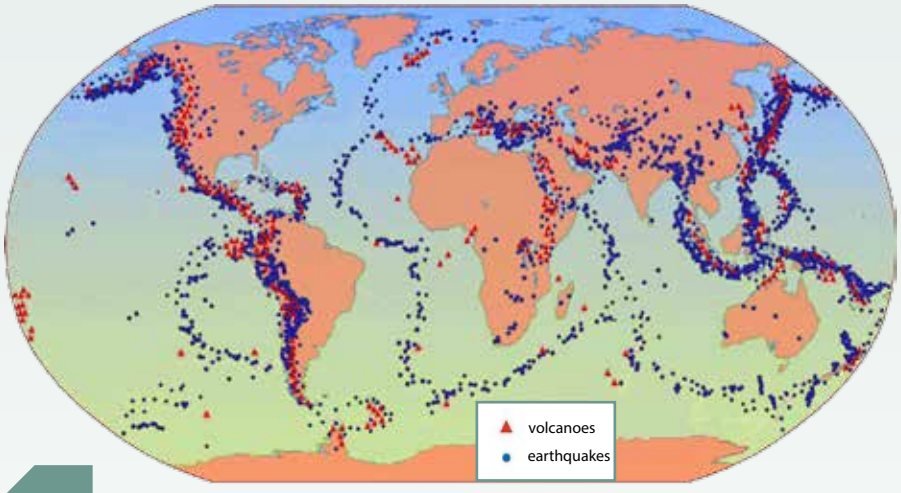
Study carefully the map below. This shows places that were struck by strong earthquakes and the location of the main volcanoes.

a. In which four of the places listed below do we find the largest concentration of volcanoes?

b. Mention two other places where we find many active volcanoes.
c. On the map mark the Pacific Ring of Fire. Why do you think is this called so?
d. Use the atlas in order to mark the following volcanoes on map B. Etna, Fuji, Tambora, Cotopaxi, Krakatoa, Ruaperu, Mt St Helens and Katmai.
e Are there any similarities between the location of the volcanoes and the tectonic plate margins?
f. Mention the two tectonic plate margins near which lies each of the following volcanoes.

Central Australia		Japan	
Iceland		Central Mediterranean	
Sahara Desert		Greenland	
Eastern regions of North America		Western coast of America	

volcano	Tectonic plate	Tectonic plate
Eyjafjallajökul in Iceland		
Tambora in Indonesia		
Cotopaxi in Ecuador		



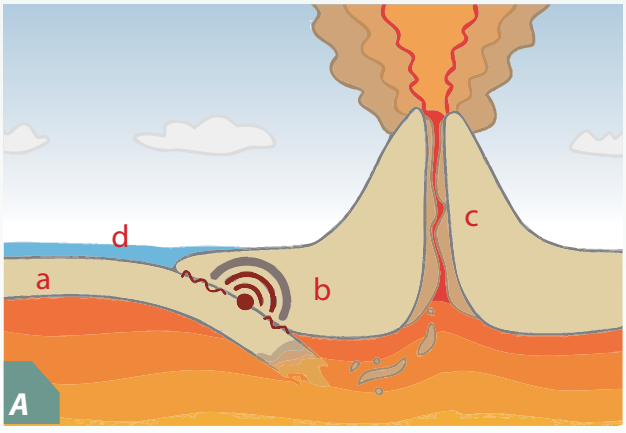
g. Use the map to explain where the strongest earthquakes have occurred.
h. During the day three strong earthquakes have struck these cities. Which two tectonic plates have caused the earth movement in each place?

- Tokyo in Japan
- Delhi in India
- The Azores in the Atlantic Ocean

4

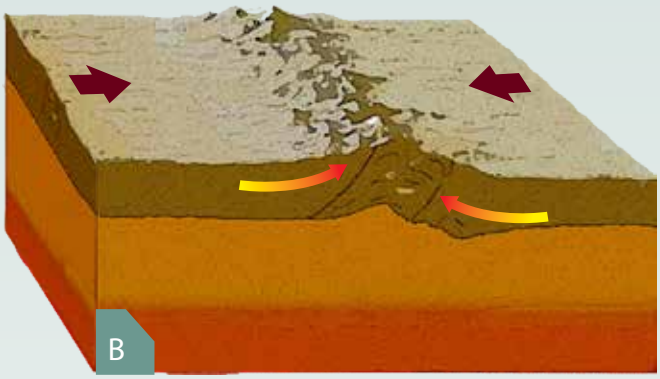
Diagram A shows how the Andes mountain in South America was formed.

a. Name the tectonic plates A and B.
b. Name mountains C and ocean D.
c. Draw two arrows to show the direction of movement of the tectonic plates.
d. Mark with letter E the place where the friction between these two tectonic plates is taking place.
e. What is such a tectonic margin called?
f. Explain why and how such strong earthquakes occur in this tectonic margin.



g. Diagram B shows us how the Himalaya Mountains in Asia were formed. State whether the information about the formation of this mountain range is true or false.

	True	False
The Himalaya mountain range is situated on a collision margin between two tectonic plates.		
The Indian and Eurasian plates are moving away from each other.		
The Himalaya mountains, including Everest keep on rising through the continued pressure of tectonic plates.		
The movement of these two tectonic plates cause destructive major earthquakes.		
As can be seen in diagram B in collision plate margins no earthquakes occur but much hot lava is emitted.		
The Indian and Eurasian plates are pushing and pressing against each other.		
In time the Himalaya Mountains will subside under the crust and will no longer be visible.		
The tectonic plates are bending, crushing and raising the rock.		



h. Around the Mediterranean Sea we find high mountain chains which were formed in the same way as the Himalaya.

i. Mark the following mountains on a map of the Mediterranean: Pyrenees, Alps, Apennines, Dinaric Alps, Pindus, Taurus and Atlas.

ii. In a few words, explain how the sedimentary rock of which these mountains are formed is now situated at such a high altitude.

5

Study carefully the diagrams on the right which show tectonic plate movements.

a. Choose the right answer.

i. At a constructive margin one of the tectonic plates is

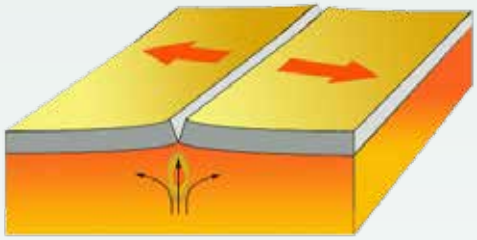
1 scraping and moving past the other.
2 moving away from the other.
3 crushing the other.

ii. At a destructive margin one of the tectonic plates is

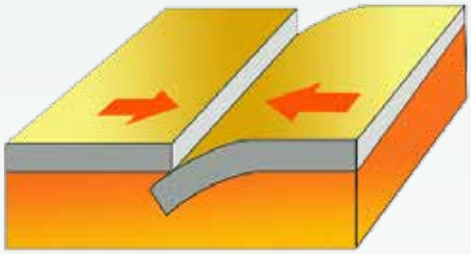
1 moving away from the other.
2 moving towards the other.
3 sliding under the other.

iii. In a constructive margin the tectonic plates are

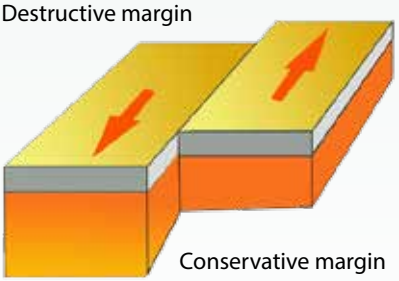
1 scraping past each other.
2 crushing and raising the crust.
3 sliding under each other.



Constructive margin



Destructive margin



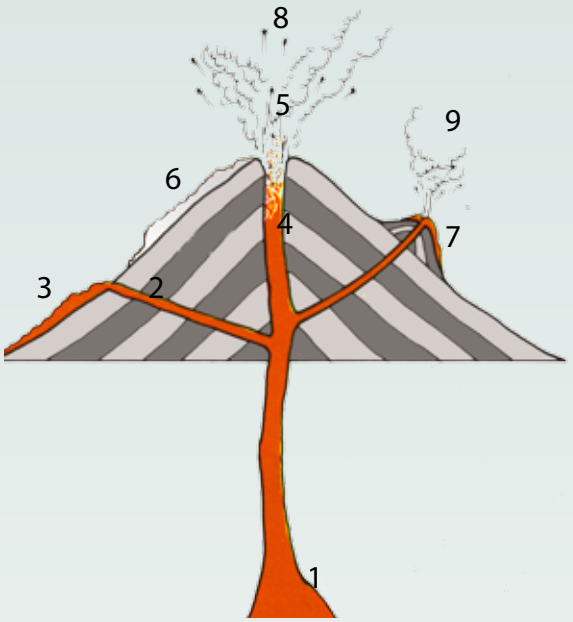
Conservative margin

6

The drawing on the right shows the structure of a volcano.

a. Write what can be found in the places from 1 to 9 by inserting the number or name in the boxes below.

	2
	1
secondary crater	
	4
	5
volcanic smoke, steam and gases	
pyroclastic cloud	
volcanic rock and cinder	
	3



b. With the help of words written in exercise 6 (a), explain what happens when a volcano erupts.

c. Mention a type of tectonic margin where volcanoes can be found. Explain how volcanoes are formed at this type of tectonic margin.

d. Explain why some volcanic mountains have gentle slopes while others have steep slopes.

e. What are the following called?

i.	A large magma store in the earth's crust.	
ii.	The deep hole at the top of a volcano from which lava flows.	
iii.	The passage which joins the magma chamber to the volcanic crater.	
iv.	The mountain made up of layers of ash and lava.	
v.	The fine material emitted during a volcanic eruption.	
vi.	The magma flowing down slowly by the slopes of a volcano .	

7

Read carefully this article taken from a geographical magazine.

There are more than six hundred active volcanoes around the world which occasionally erupt without warning. Although these are dangerous, we still find millions of people who live close to them. In fact it is estimated that about 500 million people live near active or dormant volcanoes. There are many volcanoes in Italy and in the surrounding seas. The most active is Etna in Sicily which is more than 3,000 metres high. Near Naples we find Vesuvius which is famous for destroying the Roman cities of Pompeii and Herculaneum in the year 79 AD. The last time it erupted was in 1944 but it still remains a threat to this city.

About 175 kilometres away from Naples is Mersili, a volcano as large as Etna which, however, is totally submerged under the sea. Although it has been dormant for a long time, Italian seismologists think that it may erupt suddenly with disastrous results. In the Tyrrhenian Sea to the north-west of the city of Messina, there are some of volcanic islands among which Stromboli, Vulcano and Lipari. Stromboli is quite active and is nicknamed the lighthouse of the Mediterranean since volcanic gas and smoke is continuously emitted. Close to Malta we find two other volcanic islands, Linosa and Pantelleria. The latter erupted about 120 years ago and the volcano is now dormant. The presence of so many volcanoes in the centre of the Mediterranean is the result of the tectonic margin between the African and Eurasian plates. These two plates are pressing against each other and in some places the African plate is sliding under the Eurasian one. The millions of people living near these volcanoes are in continuous danger. These volcanoes may suddenly erupt and bury whole cities underneath the ash, cinder or mudslides. Lava flows and pyroclastic cloud may also cause considerable damage to buildings and the environment as well as endanger people's lives.

a. On the map of the central Mediterranean mark all the above mentioned volcanoes.
b. What is the difference between an active and a dormant volcano?
c. From the extract give examples of an active and a dormant volcano.
d. Italian seismologists have lately found out that the slopes of Mersili volcano are very fragile and if it erupts these can collapse and cause very high waves.
   i. What are these high waves called?
   ii. If this happens, what damage can be caused?
   iii. Mention some cities that can be struck by these waves.
   iv. Is Malta in danger if this happens?

e. What is a volcanic island? Give two examples in the Mediterranean.
f. Explain why we find a vast concentration of volcanoes in the central Mediterranean.
g. Which are the main tectonic plates in the Mediterranean? Explain how they cause volcanic activity in the Mediterranean.
h. Why are the people who live near these volcanoes in great danger?
i. Give one reason why these people still choose to live near volcanoes.

8

Imagine that you are a journalist writing for local newspaper. News has just broken about a massive eruption by volcano Etna. The editor has charged you with writing a main front page article about this volcano for the newspaper.

a. Use website in order to find the necessary information. In the article include:
   i. an eye-catching title
   ii. a map of the central Mediterranean showing the location of
      - Etna and
      - the city of Catania.
   iii. what usually happens during a gigantic eruption,
   iv. information about past eruptions of Etna,
   v. the dangers caused by these past eruptions,
   vi. the beneficial effects of a volcano for the local people.

b. Find some pictures of volcanoes which erupted in the past and underneath write some information to explain what happened.

9

Look carefully at pictures A, B, C and D which show the damage that can be caused by volcanic eruptions.

a. What is the material being emitted from the crater of the volcano in picture A called?
b. Explain how an eruption like the one in picture A can affect very distant countries.
c. What damage can the lava flow in picture B cause?
d. What is the cloud seen rolling down the slope of the volcano in picture C called?
e. What is the cloud in picture C composed of and what damage can it cause?
f. A volcano which erupted near the village in picture D left total devastation. Explain what happened.

10

As can be seen in the picture below, a tremor lasting only a few seconds can cause extensive damage.

a. What caused the earthquake?

b. Imagine that you live in the city where the earthquake shown in the picture occurred. Write about:

- What you saw when you came out of home upon feeling the tremor.
- What help you need.

c. Join correctly these sentences about the measurement of the intensity of earthquakes.

Earth tremors are measured with the use of	of an earthquake from 1 to 10.
A seismograph measures the intensity	is barely felt by people.
The Richter scale measures the intensity	an instrument called seismograph.
A tremor which measures 2 on the Richter scale	causes considerable damage.
An earthquake measuring 7 or more on Richter scale	the direction and duration of a tremor.

11

More than 20,000 dead in Turkey

17 August 1999

A massive earthquake measuring 7.4 on the Richter scale struck the city of Izmit in Turkey this morning at 03:00. The ground shook for 37 seconds and the damage was considerable. The authorities have already put an estimate of 20,000 people dead and half a million homeless. The earthquake was also strongly felt in Istanbul 70 kilometres away from the epicentre. A large number of houses apartments, factories, offices, roads and bridges were destroyed. Many people are buried under the collapsed houses and many volunteers are searching for the dispersed and offering first aid. Electricity cables are broken on the road and the surviving houses have no electricity or water. Fire broke out at an oil refinery in the city of Tüpas and since early this morning fire-fighters are trying to extinguish it with the help of appropriate aeroplanes. The earthquake also caused 2 metre high waves in the Sea of Marmara. Part of the coast collapsed and is now submerged.

Read this extract from a local newspaper and then answer the following questions.

a. List all the damage caused by the earthquake at Izmit and the neighbouring region.

b. What do the terms epicentre and Richter scale mean?

c. Why was the death toll so high?

d. What do you think would be the problems for the inhabitants of Izmit in the immediate future?

e. Explain why Turkey is continuously in danger of being struck by strong earthquakes.

f. Mention other Mediterranean countries that have been hit by strong earthquakes.

g. What do you think should be done in earthquake-prone countries to avoid high mortality during tremors?

12

Through the years many strong earthquakes hit the Mediterranean, killing or injuring a lot of people. Among these one can mention those of Lisbon (1755), Chios (1881), Messina (1908), Abruzzo (1915), Agadir (1960), Campania/Basilicata (1980), Athens (1999), Izmit (1999), L'Aquila (2009), Van (2011).

a. The map shows us the location of these earthquakes. Near each epicentre shown on the map write the name of the place and the date of the earthquake.

b. Use the internet, books and other sources to find information about two of these earthquakes. Write about:

- the date and place of the earthquake,
- the cause of the earthquake,
- its intensity,
- what happened during the tremors,
- problems faced by the survivors after the earthquake.

c. Draw a map of the place and locate the epicentre. Find some pictures and under each give some information about the damage sustained by the place.

13

Read carefully this extract taken from the book *Storja ta' Malta u Għawdex* (A History of Malta and Gozo) by Giovanni Faure (1917).

At half past six in the dark of a quiet and calm morning on 28 December 1908 a most curious happening occurred suddenly. The sea at once rose by six feet (about 2 metres). At Marsaxlokk the sea entered the homes and shops and the inhabitants fled to the hills. The same thing happened at Birżebbuġa, St George's Bay (Birżebbuġa) and Marsascala; at St Julians, Sliema and Msida the sea overflowed the quays; cars, animals and people had to stop and find shelter, but after a few minutes the sea suddenly retreated to a level much lower than normal and the seabed was uncovered for long stretches of coast and in the harbours of the south-east it destroyed many walls, and threw up and left stranded here and there in the fields many fishing boats and kajjikki, together with a lot of fish.
Many people and fishermen risked their lives; the parish priest of Marsaxlokk almost lost his life. In the other ports the ships chains were snapped, other sea crafts broke the thick lines and were battered against each other.
Many domestic animals perished but fortunately no person died and only a few were injured since it was early in the morning. While this phenomenon was occurring in Malta, Sicily and Calabria there struck by an immense catastrophe with earthquakes, fires, destruction and the loss of an innumerable amount of people and animals.

a. Explain what happened in Malta on 28 December 1908.
b. What is this phenomenon called?
c. Why do you think this happened?
d. What were the effects of this phenomenon on Malta?
e. Use the internet to find information about what happened at Messina and Reggio Calabria that same day on 28 December 1908.

A

acid rain
xita aċiduża
Rain mixed with toxic gases originating from human activities that generate sulphur dioxide and nitrous oxide. This rain kills trees and fish in lakes, weakens the soil and quickens the rate of weathering.

active volcano
vulkan ħaj / attiv
A volcano which erupts regularly.

afforestation
afforestazzjoni
The planting of many trees in an area to form a wood or forest.

agriculture / farming
agrikultura / biedja
The raising of crops in the fields and animal husbandry in the farms.

animal manure
demel naturali
Dry animal waste that is mixed with soil to increase fertility.

arable farmer
bidwi
A person who cultivates the fields.

atmosphere
atmosfera
The gaseous layer which covers the earth, made up of a mixture of nitrogen, oxygen, carbon dioxide, water vapour and other gases.

B

bay
bajja
An inlet on the coast.

biodiversity
bijodiversità
The variety of different species which live in a particular environment.

Biofuel
bijofjuwil
An alternative fuel made out of oil extract of sunflower, soyabean, maize or sugar cane.

biomass
bijomassa
Organic matter like animal dung, waste, maize and sugar cane which store light energy from the sun in chemical form. This material can be refined into fuel or gas that can be used to generate energy.

blue clay
tafal
Soft rock coloured light grey which darkens when wetted. It breaks easily and when wet slides down slopes covering the underlying layers of rock. It is the only impermeable rock in the Maltese Islands. Consequently many natural springs flow out of this layer.

borehole
spiera
A deep hole in the rock purposely dug to pump up water.

boulder scree
tirxa
A large rock that collpses from the cliff face and rolls down the slope to sea.

C

calcareous
kalkarju
Rock that contains a high percentage of lime or calcium carbonate, like globigerina.

carbon footprint
marka tal-karbonju
The average amount of greenhouse gases such as carbon dioxide that a person or building produces and emits every year into the atmosphere.

carbonate raw soil
ħamrija tal-bajjad
A whitish soil derived from the blue clay layer which contains a lot of calcium carbonate.

carnivore
karnivoru
Creatures that eat meat.

cave
għar
A natural cavity or hollow in the ground such as those at Għar Dalam or Għar Lapsi near the sea.

channel/strait
fliegu
A narrow stretch of sea which divides two islands or countries, such as North Comino Channel between Gozo and Comino.

chlorofluorocarbons
kloroforocarbons
Artificially produced gas made out of chlorine, fluorine and carbon which were until recently used in the production of spray-bottles and refrigeration. This gas is now prohibited since it damages the ozone layer.

citrus
ċitru
Slighly acidic fruit including oranges, lemons and mandarines.The citrus fruit trees are evergreen. Their leaves are shiny dark green and quite fragrant when crushed. Citrus trees bloom in March and April.

cliff
sies
A steep slope of land rising from the sea.

Climate
klima
The average weather conditions for a long time.

climate change
bidla fil-klima
A change in the average global temperature due to natural causes such as a volcanic eruption or to human activities that increase greenhouse gases in the atmosphere.

cloud
sħaba
Water-vapour that has condensed into buoyant tiny water-droplets at different altitudes. When loaded it becomes heavy and rain follows.

coast
kosta
A land immediately close to sea.

collision margin / boundary
xifer ta' kolliżjoni
The edge of two plate margins that are moving towards each other. When they collide, they press each other upward to form high mountains such as the Himalaya and the Alps.

conglomerate
konglomerat
Sedimentary rock made up of a mixture of pebbles, particles and dust.

conservative margin / boundary
xifer konservattiv
The edge of two tectonic plates that are moving past each other. The crust is neither being created nor destroyed.

constructive margin / boundary
xifer kostruttiv
The edge of two tectonic plates that are moving away from each other. New crust is thus being formed by the magma which is outflowing from the mantle.

continent
kontinent
One of the large land-masses in the world such as Europe, Asia, Africa, America and Australia.

convection currents
kurrent konvezzjonali
Currents of magma flowing under the earth's crust caused by the great heat present in the mantle and which are strong enough to move and carry the tectonic plates above them.

coral
qroll
Creatures having calcareous cover that live in shallow warm seas. Often these aggregate to form coralline reefs.

crater
bokka ta' vulkan
Deep hole on the surface of a volcano from where lava, ash and cinder are emitted during an eruption.

D

dam
diga
A high wall which contains the waters of a river. A dam is built to generate hydro-electric power, store water and control floods.

debris
terrapien
A mixture of soil and stone chippings.

deforestation
deforestazzjoni
The cutting of trees in woods and forests so that the land may be used for other purposes.

delta
delta
A triangular region at the river mouth made up of silt carried down and deposited by the river.

deposition
depożizzjoni
Silt that had been weathered, transported and deposited by means of running water, glaciers, waves and wind.

desalination
desalinazzjoni
A process by which seawater is turned into potable freshwater.

desert
dežert
A large and dry expanse of land upon which few creaturs can live. Some deserts like the Sahara are mostly made up of fine sand deposited in high sand dunes.

destructive margin / boundary
xifer distruttiv
The edge of two tectonic plates that are moving towards each other. As they press against each other one of the plates will slide under the other and be destroyed in the mantle.

dew
nida
Tiny water droplets usually seen at dawn. It is the result of water vapour turning into droplets when it comes into contact with a cool surface.

dockyard / shipyard
tarzna
A seaside industrial zone furnished with docks, cranes, workshops and other equipment for the building and repair of ships.

doline
dolina
A deep hole formed by the collapse of a cave such as the one at Maqluba in Qrendi.

dormant volcano
vulkan rieqed / inattiv
A volcano that shows no sign of activity, but which still can suddenly erupt in future.

dumpyard
radam
Places such as abandoned quarries where clean construction waste is thrown away.

dust of globigerina limestone
xaħx
Fine dust that is a by-product of the quarrying and cutting of lower globigerina limestone (softstone). The stone masons mix it with a little cement and water to place in between the building stones.

E

earth tremor
theżżiża sismika
An earth movement which shakes the ground.

earth's crust
qoxra tad-dinja
The solid layer of hard rock at the surface of the earth.

earthquake.
terremot
An erath tremor that can cause much damage.

ecosystem
ekosistema
The interaction between a community of organisms and their environment.

energy saving bulb
bozza tiffranka l-enerġija
A light bulb which uses only 20% energy of a normal bulb. It also lasts much longer than a traditional filament bulb.

environment
ambjent
The natural place and the surrounding areas where people, plants and animals live.

Epicentre
epiċentru
The place on the earth's surface where the seismic wave starts thus creating most damage.

epidemy
epidemija
An infectuous disease that spreads quickly from one place to another.

epoch
epoka
A long stretch of time in the geological history of the world. We are now living in the Holocene epoch of the Quaternary period.

erosion
erożjoni
The natural process by which rock is broken and carried away. This is done by means of seawaves, wind, rivers and ice. The rock is weathered, transported by these agents and later deposited in another place.

evaporation
evaporazjoni
The process by which water turns to gas by heating.

extinct
estint
Anything which no longer exists since totally destroyed.

extinct volcano
vulkan mejjet / estint
A volcano which has not erupted for the past two thousand years at least.

extrusive volcanic rock
blat ignijuż estruživ
Magma which is emtted by the volcano and solidifies into lava or basalt.

F

fertiliser
fertilizzant artifiċjali
Chemicals that are mixed with soil by the farmer so that it producer better and more abundant crops. Fertilisers are useful in order to replenish the soil with the nutrients which had been used up by the plants or crops.

fission
fissjoni
The breaking up of uranium atoms in a nuclear reactor to produce much energy.

fissure
dagħbien
A very steep and deep crack in the rock.

flat land
wita
A stretch of flat country.

floods
għargħar
Occur when the land is covered in water mostly due to rivers overflowing their banks. Floods may also occur by means of high waves caused by high winds or an earthquake during a tsunami and after the ice melts in Spring.

flora
flora
All plants species.

focal point
punt fokali
The precise underground place where the rock movement which causes an earthquake takes place.

forest
foersta
A large area full of trees.

fossil
fossila
The remains or the mould of a creature deposited in sedimentary rock.

fossil fuel
fjuwil fossil
Fossil fuels are the remains, in the form of coal, oil and gas, of creatures that lived millions of years ago. Thes are mostly used in power stations.

frost shattering /freeze-thaw weathering
tmermir bil-ġlata
The process that is frequent in cold climates by which water in the rock freezes and expands by night, thus breaking up the same.

G

garrigue / scrubland
xagħri
A limestone ecosystem with low and dense shrubs. The landscape is full of holes and pointed or razor-shaped rock.

geologist
ġeologu/ġeoloġist
A scientist who studies the origin, structure and formation of rock.

geothermal energy
enerġija ġeotermali
Energy used mostly in volcanic regions as in Iceland, New Zealand and parts of the United States. Geothermal power stations use the internal heat energy of the earth to produce electricity.

geyser
geyser
A water or steam spout which is emitted regularly with force from a volcanic fissure.

glacial period
era glaċjali
A geological period of time when the global climate cools in such a way that the ice caps in the poles and on mountains spread out and cover vast world regions.

glacier
glaċier
A river of ice which flows slowly down a valley in between mountains.

gorge
ħondoq
A narrow and deep steep-sided valley.

greenhouse
serra
A structure situated in fields, that has a cover of plastic or other material which allows the sun's rays to penetrate. Crops are grown in a controlled envieonment.

greenhouse effect
effett serra
The process by which some gases such as carbon dioxide keep much of the earth's heat energy from being lost to space. The same happens in a greenhouse where the plastic cover allows the sun's rays to filter in but keeps the heat from escaping.

greenhouse gas
gass serra
Atmospheric gases which absorbs the heat energy that is reflected back from the earth. The most common are carbon dioxide , methane and nitous oxide.

greensand
rina
A thin and soft layer of orange-coloured rock. It is also called 'rina' (sandy) or 'ġebla safra' (yellow stone) in Maltese. It is easily weathered and large greensand boulders collapse and roll down slopes.

H

harbour
port
An inlet where people have developed quays for the sheltered berth of ships so that they may load or unload cargo and people.

heat wave
mewġa ta' sħana
A period of much higher than average temperatures during which the land dries making forest fires possible.

hemisphere
emisfera
Half the world, as divided into two from the Equator forming the Northern and the Southern Hemispheres. The world can also be divided into two from the Greenwich Meridian and the 180° meridian forming the Western and Eastern Hemispheres.

herbivore
erbivoru
An animal that eats only plants.

hurricane
uragan
Tropical storm with high winds and heavy rain.

hydroelectricity
enerġija idroelettrika
Clean energy produced by the force of water. Hydroelectric power stations are mostly found where rivers flow swiftly down steep mountains.

hydrosphere
idrosfera
All the waters of the oceans, seas, lakes, rivers, ice-caps, glaciers, as well as groundwater.

I

ice / hail
silġ
Water that solidifies at below 0°C. It can also consist of icy raindrops similar to beads.

ice age
żmien is-silġ
A very cold period of time when the ice-caps at the Poles and on mountains expands and spread over vast territories.

igneous rock
blat ignijuż
Volcanic rock which forms when magma solidifies.

impermeable
impermeabbli
A type of rock which absorbs water without letting it flow further downward, for example, blue clay.

incinerator
inċineratur
A large furnace which burns waste at very high temperatures.

indigenous
indiġenu
Organisms that had always inhabited a particular place, for example, Aleppo pines and oak trees in Malta.

industrial revolution
rivoluzzjoni industrijali
The age when machines were first introduced in manufacture and products were no longer done exclusively by hand. Factories were built and coal was the prime source of energy. This change started in Great Britain in the eighteenth century and then spread to Western Europe and the United States.

infiltration
infiltrazzjoni
The process by which water goes down the soil until it reaches the bedrock.

inner core
qalba ta' ġewwa
The innermost layer at the centre of the earth, made up of solid rock with a temperature as high as that of the sun's surface.

interglacial period
perjodu interglaċjali
An interval between one ice-age and anothetr in which the global temperature rises and the ice-caps melt down, being only left in the Poles and mountain-tops.

intrusive volcanic rock
blat ignijuż intruživ
Magma which solidifies slowly underground, for example granite.

invertebrate
invertebrat
Creatures that have no spinal cord, for example, octopus and insects.

irregular immigrant
immigrant irregolari
A person which enters a foreign country without permit.

island
gżira
A land or country totally surrounded by sea such as Malta.

K

karst
karst
A stretch of land that is made up of calcareous and porous rock, charcterised by cracked and razor-shaped rock. Underground there are usually many caves and passage ways.

L

lake
għadira
An area covered by freshwater.

landfill
miżbla
A place where all type of uncontrolled waste is thrown.

lava
lava
Molten rock that is emitted by a volcano and which cools and solidifies in time.

lava flow
nixxiegħa ta' lava
A river of molten rock or magma flowing down the slopes of a volcano.

lichens
likeni
Small plants made up of white, grey, black or yellow blobs which grow flat upon rocks or tree trunks.

lime
ġir
A fine dust derived from coralline limestone which is used for plastering and painting.

lithosphere / crust
litosfera / qoxra
The earth's crust made up of the continents and the oceanic floors.

lower coralline limestone
qawwi ta' taħt / żonqor
A very hard rock also known in Maltese as 'qawwi ta' taħt'. It forms high perpendicular cliffs or garrigue landscape with many holes and razor-shaped rock.

lower globigerina limestone
ġebla tal-franka
The lowermost sub-layer or member of globigerina limestone formation, also called 'tal-franka' in Maltese, which is used for building stone.

M

magma
magma
Molten rock which is found under, or inside, the earth's crust.

magma chamber
ħawt vulkaniku
A large store of magma in the earth's crust.

main volcanic vent
arterja vulkanika
A vertical passageway in a volcano which joins the magma chamber to the main crater, whence magma flows on its way out.

mammal
mammiferu
A hair or fur covered creature. The female carries on a pregnancy, give birth and nurses the young. Examples include human beings, dolphins, bats, hedgehogs and weasels.

mantle of the earth
mantell tad-dinja
The layer in between the crust and the core of the earth. Parts of this lay are solid while others are molten.

mean sea level aquifer
ħażna tal-ilma tal-pjan
Rainwater stored in the pores and fissures of the globigerina limestone and lower coralline limestone.

Mercalli scale
skala Mercalli
A system by which the intensity of an earthquake is calculated by observation of the damaging effects, on a scale of grades ranging from1 to 12.

metal
metall
Hard mineral that can be molten and given another shape, like iron, silver, gold and aluminium.

metamorphic rock
blat metamorfiku
Rock which changes its structure through pressure or great heat. This happens for example when limestone turns to marble.

metereological station
uffiċċju meteoroloġiku
A place where experts try to predict the weather by means of appropriate instruments.

methane
metanu
Inflammable, odourless and colourless natural gas which is mainly formed during decomposition of waste in landfills or the cultivation of rice.

microscopic organism
organiżmu mikroskopiku
A very small creature that is only visible through a microscope.

middle globigerina limestone
globiġerina tal-qargħajja
The middle sub-layer or member of globigerina limestone formation. It is easily weathered and broken.

migration
migrazzjoni
The movement of people from one place to another for social, economic, political or environmental reasons.

mineral
mineral
Natural resource that is mined from underground, like bauxite (aluminium), iron, diamonds and gold.

mollusc
mollusk
Boneless and soft-bodied creatures such as snails, shells, squids and octopus. They may develop a shell for protection.

mountain
muntanja
High land with steep slopes. A mountain may rise singly or in a series called mountain chain or range such as the Alps.

mudflow / lahar
valanga ta' tajn
A mass of mud which slides down the slopes of a mountain or volcano.

N

natural hazard
diżastru naturali
A disaster that happens through natural processes such as floods, great storms and earthquakes.

natural resource
riżorsa naturali
Useful materials that are not man-made such as oil, water and coal; a variety of minerals like gold, iron and salt; as well as forests, animals, fish and plants.

neptune grass
alka
A marine plant which blossoms in Spring and bears fruit in Autumn, scientifically known as *posidonia oceanica*. It has long leaves like ribbons and rhizomes which anchor it well to the sand. It forms large meadows on the seabed where fish and other creatures shelter and nest.

non-renewable energy
enerġija ma tiġġeddidx
Energy source, such as coal, oil and gas, which took many millions of years to form underground and which is now being depleted since used at a very fast rate.

nuclear cloud
sħaba radjoattiva
A mass of radioactive air originating from a nuclear explosion.

nuclear energy
enerġija nukleari
Energy produced by fission, that is the breaking upof the atom of uranium in a nuclear reactor. In this process great heat is produced to turn water to staem. The latter will then turn the turbines and generate elctricity.

nuclear radioactivity
radjoattività nukleari
Rays originating from nuclear power stations which may destroy all life forms.In order that radioactivity is avoided the nuclear reactor is covered by a concrete dome,since this is the only material which stalls these rays.

nuclear reactor
reattur nukleari
The core of a nuclear plant where the uranium atom is split by smaller particles to produce a chain reaction that emits great energy.

O

ocean
oċean
A very large tract of seawater such as the Atlantic Ocean between America, Europe and Africa.

oil refinery
raffinerija taż-żejt
An industrial plant where crude oil is turned into other useful products for industry and transport such as petrol, diesel, kerosene, grease and asphalt.

onion-skin weathering
tmermir folja folja
The process by which rock is broken down in layers by continuous expansion during the day and contraction during the night.

outer core
qalba ta' barra
The layer of molten rock situated between the mantle and the inner core of the earth.

ozone layer
saff tal-ożonu
A layer of gas at about 25 kilometres altitude which protects us from the ultraviolet rays of the sun.

P

Pacific ring of fire
Ċirku tan-nar tal-Paċifiku
The most extensive seismic zone with many volcanoes and earthquake events all around the Pacific Ocean. It is made up of a series of 425 volcanoes some of which submerged. It starts at the southern tip of South America, runs through all the west coast of America, crosses over the Aleutian and Kuril Islands, and down to Japan, the Philippines and New Zealand, a distance of 40,000 km.

Pangaea
Pangaea
The enormous landmass that existed about 300 million years ago which comprised all the present continents joined together.

perched aquifer
ħażna tal-ilma ta' fuq it-tafal
Rainwater which deposits in the pores of the greensand and upper coralline limestone layers above the blue clay.

permeable
permeabbli
Rock through which water can pass.

photovoltaic / solar panel
pannella fotovoltajka / solari
A structure which turns the sun's rays into electricity.

pillar
plier
A column extending from the ceiling to the ground of a cave. It is composed of calcium that is left when water drips down the ceiling of a cave.

plate margin / boundary
xifer ta' qoxra tettonika
The edge of tectonic plates that move towards, away from or past each other. This is a very seismically active area.

pole
pol
The points at the North Pole, situated in the Arctic Ocean at latitude 90° North of the Equator, and the South Pole, situated in Antarctica at latitude 90° South of the Equator, through which the axis of the earth passes.

pollution
tniġġis
The damage caused to the natural environment such as the air, water, soil and creatures, by human activities.

pottery
fuħħar
The produce of clay that is baked in an oven.

power station
power station
A large factory where electricity is generated. Many are fire-powered by fossil fuels to boil water into steam which turns the turbines that operate the electrical generators. The electricity is then distributed to consumers.

precious stone
ħaġra prezzjuża
A rare and dear mineral found underground, such as diamonds, emeralds, rubies and sapphires.

precipitation
preċipitazzjoni
Part of the hydrological cycle when water falls down back to earth in the form of rain, ice or snow.

pumice stone
ħaffiefa
A whitish, light and buoyant volcanic rock with many pores.

pyroclastic flow
daħna piroklastika
An avalanche of volcanic ash, pumice stones, cinder, rocks and gases which are emitted from the crater and roll downslope at more than 100 km per hour. This cloud with a temperature of more than 500°C, drags along and burns whatever comes its way.

Q

quarry
barriera
A place used for excavating rock for building stone and material.

quaternary deposits
depożiti kwaternarji
A thin layer of soil and silt that had been carried by water in the quaternary period and which generally deposits by the sides of valleys.

quay
moll
A strong seawall built to contrast waves. Ships berth by quays to load or unload cargo.

R

radioactive rain
xita radjoattiva
A very destructive toxic rain which falls after a nuclear explosion.

radioactive waste
skart radjoattiv
The remains of the uranium rods that are left in the nuclear reactor after energy generation. These are stored in underground concrete bunkers since they are harmful to health.

raw material
materja prima
Natural resource like oil, gold, copper and trees that can be processed into manufactured goods.

recycling
riċiklar / riċiklaġġ
The process by which an object which has been discarded is put to another use.

reef
sikka /skoll
A rock lying just below sea-level, often very dangerous for shipping.

renewable energy
enerġija tiġġedded / rinnovabbli
Energy produced from natural sources that will not run out, such as wind, sun and water. These are clean sources of energy and do not harm the environment.

reptile
rettili
An egg-laying animal with scales that prefers to spend time in the sunshine.

Richter scale
skala Richter
An automatic system of determing the intensity of an earthquake with grades from 1 to 10.

river mouth / estuary
fomm ix-xmara
The place where a river joins or drains into the sea.

running surface water
ilma ġieri
Water which comes out of a natural spring.

S

salinity
salinità
The amount of salt in the sea or in soils.

sand
ramel
Fine rock particles weathered by wind and water which deposits on the beaches, the seabed, valley sides and deserts.

sandstorm
maltempata tar-ramel
High winds that carry considerable amounts of sand in the desert.

seaquake
maremot
An earthquake having the seabed for epicentre. If strong enough such seaquake may cause a tsunami.

sedimenary rock
blat sedimentarju
Rock composed of mud, sand, silt and remains of creatures which are deposited in layers on the seabed and solidify by pressure.

sediment
naqal
All the material or load that a river carries such as soil, dust, branches, canes and stones.

seismic trace
traċċa sismika
The line which the seismograph pen marks on the chart during the tremors of an earthquake.

seismogram
sismogramma
A seismic chart marked with the lines of the seismograph as registered by a seismograph during an earthquake.

seismograph
sismografu
An instrument that measures and records the intensity and duration of earth movement during an earthquake.

seismologist
sismologu / sismoloġist
A scientist who studies the origin, geographic locations, effects and probability of earthquakes.

sheer cliff
rdum
A perpendicular rock feature rising from the sea as found at Dingli or Ta' Ċenċ Cliffs.

shore
xatt / xtajta
The land adjacent to the sea.

shrub
arbuxxell
A rounded plant or small tree such as thyme and spurge.

soil
ħamrija
Stone particles and organic remains like worms and leaves that is necessary for cultivation of plants and crops.

soil sediment
ħamla
The material carried by a river or deposited by floods.

solar furnace
forn solari
A large structure that uses the sun's heat to produce high temperatures. The rays of the sun are attracted by large parabolic mirrors that reflect them on to a focal point. This heat amounting to 3,500°C will then be used for electricty production.

species
speċi
Group of organisms having similar characteristics.

sponge
sponża
An animal that lives attached to the seabed. Its skin is hollowed and full of pores.

spring / water course
nixxiegħa
A course of running water.

stalactite
stalaktita
A cone shaped feature which hangs from the ceiling of caves that is made of calcium carbonate left over from water droplets.

stalagmite
stalagmita
A column rising from the ground of a cave, that is made out of calcium carbonate which is deposited by the droplets of water.

storm
maltempata
Atmospheric condition with high winds, heavy rain, thunder and lightning.

stratosphere
startosfera
An atmospheric layer situated between 10 and 50 kilometres high, where no cloud or storms are present.

sustainability
sostenibbiltà
The careful use of resources, so that they may not be harmful to the environment and would still be available in the distant future.

T

tectonic plate
qoxra tettonika
A large piece or block of the earth's crust which slowly moves over the mantle due to tectonic movement.

temperature
temperatura
The measure of how hot any object is, usually in degrees Celsius.

terra rossa
ħamrija tal-ħamri
Reddish soil found mostly where coralline limestones lie at the surface. The colour is derived from iron oxides in these types of rock.

Tethys Sea
Baħar Tethys
A large sea which existed about 300 million years ago and which extended from today's entrance into the Mediterranean to the Indian and Pacific Oceans. Due to tectonic movements the sea was squashed and can now be regarded as the predecessor of today's Mediterranean Sea.

thermal mud
tajn termali
Lakes and pools of warm mud as can be found in volcanic regions like Iceland and New Zealand. This has therapeutic medicinal qualities.

thermal power station
power station termali
A plant where elctricity is generated by the burning of fossil fuels.

thermal spring / hot spring
fawwara termali
A natural hot water stream.

tides
frugħ il-baħar
The onrush or ebbing of seawaters under the effect of the moon and the sun.

topography
topografija
The description of the physical charcteristics of the landscape, such as hills, mountains, plains, valleys and rivers.

tourism
turiżmu
Economic activity which caters for those who travel for leisure, sightseeing and business.

tourist resort
ċentru turistiku
A place having facilities to cater for holidaying tourists.

toxic gas
gass tossiku
Poisonous gas, produced by indutrial activity, like the smoke which comes out of power station chimney stacks when fossil fuels or petro-chemicals are burnt. These gases pollute the air, create acid rain and change climate.

transpiration
traspirazzjoni
The process by which water evaporates from plants and leaves.

transport
trasport
Travel and carriage of people and goods by means of cars, truck, trains, aeroplanes and ships.

troglodyte
troglodita
Cave-dwellers, for example pre-historic peoples.

tropical rainforest
foresta tropikali
The richest ecosystem which is found in the hot and humid regions just north and south of the Equator. In it live two-thirds of all the world's living species.

tsunami
tsunami
High waves originating from a tremor on the seabed.

U

ultraviolet rays
raġġi untravjola
Invisible rays from the sun that damage the cells of all living creatures. The ozone layer intercepts these rays and so protects us.

upper coralline limestone
qawwi ta' fuq
The most recent calcareous rock layer to develop, made up of hard rock which is quarried for spalls and building sand. It forms sheer cliffs and vast garrigue areas.

upper globigerina limestone
globiġerina tal-kwiener
The uppermost sub-layer or member of globigerina limestone formation. It is resistant to fire and heat.

V

valley -
wied
A low country between hills whence rainwater passes on to sea.

vertebrate
vertebrat
Animal which has a spinal cord, like mammals, birds, reptiles, fish and amphibians.

viscous lava
lava viskuża
A somewhat thick magma that flows out of a volcano. This type of lava forms steep-sided and high volcanoes.

volcanic ash
rmied vulkaniku
Rock particles of less than 2 mm that are emitted during a volcanic eruption. When airborne, this fine ash is blown by the wind for very long distances.

volcanic eruption
żbroff ta' vulkan
The sudden emission of lava, ash, cinder and gases from the crater of a volcano.

volcanic gas
gass vulkaniku
Gases like carbon dioxide, sulphur dioxide and steam which are emitted during a volcanic eruption.

volcanic island
gżira vulkanika
An island that is composed of lava of a volcano.

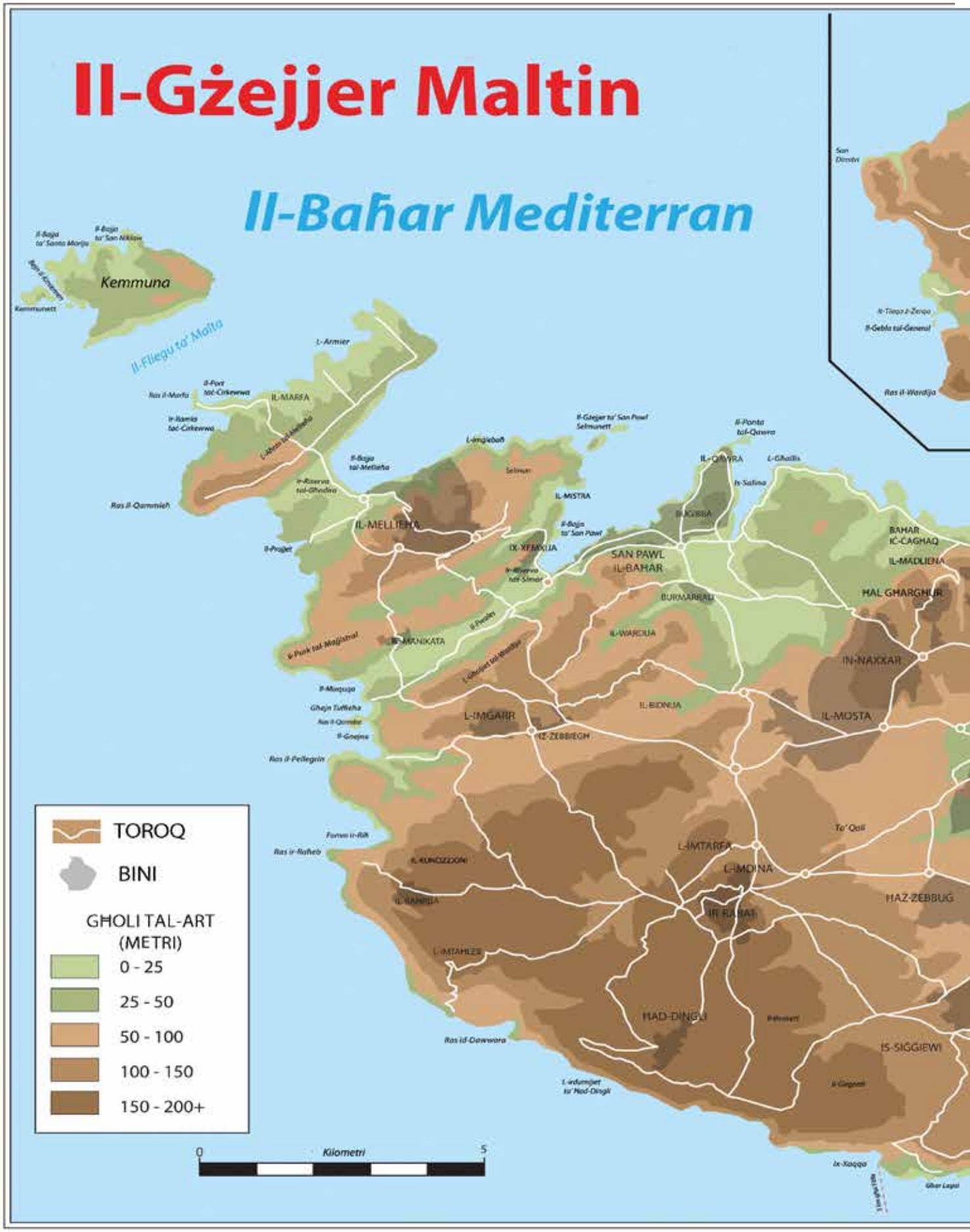
volcano
vulkan / munġbell
A hill or mountain out of which are occasionally emitted lava, cinder, ash and gases that can be harmful.

W

waste
skart
Discarded material that is no longer needed.

weathering
tmermir
The way rock is worn down and broken into smaller pieces by physical, chemical and biological processes.

wind turbine
turbina tar-riħ
A large rotor on top of a high mast that produces electricity while rotating.


Il-Gżejjer Maltin
Il-Baħar Mediterran
Kemmuna
Il-Fliegu ta' Malta
L-Armier
IL-MARSA
IL-MELLIEĦA
IX-XEMXIJA
SAN PAWL IL-BAĦAR
IL-MISTRA
IL-QAWRA
BAĦAR IĊ-ĊAGĦAQ
IL-MADLIENA
HAL GHARGHUR
BURMARRAKAT
IL-WARDIJA
IN-NAXXAR
IL-MOSTA
L-IMGARR
IŻ-ŻEBBIEGĦ
IL-BIDNIJA
Ta' Qali
L-IMTARFA
L-IMDINA
IR-RABAT
MAŻ-ŻEBBUĠ
MAD-DINGLI
IS-SIĠĠIEWI
TOROQ
BINI
GĦOLI TAL-ART (METRI)
0 - 25
25 - 50
50 - 100
100 - 150
150 - 200+
0
Kilometri
5


Għawdex
MARSALFORN
IŻ-ŻEBBUG
L-GĦASRI
IX-XAGĦRA
L-GĦARB
IR-RABAT
IN-NADUR
IL-QALA
SANTA LUĊIJA
TA' KERĊEM
IT-TRIQ TAL-GĦAJN (FONTANA)
GĦAJNSIELEM
IX-XEWKIJA
IL-MUNXAR
TA' SANNAT
IX-XLENDI
Il-Fliegu ta' Għawdex
Kemmuna
Kemmunett
Il-Fliegu ta' Malta
Malta
PEMBROKE
TAL-IBRAG
PACEVILLE
IS-SWIEQI
SAN GILJAN
TAS-SLIEMA
SAN GWANN
IL-GŻIRA
L-IKLIN
IL-BELT VALLETTA
TA' XBIEX
IL-FURJANA
IX-XGĦAJRA
IL-KALKARA
IL-BIRGU
HAL LIJA
BIRKIRKARA
HAL BALZAN
L-IMSIDA
TAL-PIETA
L-ISLA
SANTA VENERA
IL-MAMRUN
BORMLA
ĦAŻ-ŻABBAR
WIED IL-GĦAJN (MARSASKALA)
Ħ'ATTARD
IL-MARSA
IL-FGURA
RAĦAL ĠDID
ĦAL QORMI
ĦAL TARXIEN
IŻ-ŻEITUN
SANTA LUĊIJA
ĦAL LUQA
IL-GUDJA
ĦAL GĦAXAQ
MARSAXLOKK
L-Ajruport
ĦAL KIRKOP
DELIMARA
L-IMQABBA
Il-Bajja ta' Marsaxlokk
ĦAL SAFI
Il-Bajja ta' Birżebbuġa
Il-Ponta ta' Delimara
IL-QRENDI
IŻ-ŻURRIEQ
BIRŻEBBUĠA
Il-Port Mielex
BENGHISA
ĦAL FAR