Earth and Space Sciences Reference Tables Workbook

Based on the New York State Earth & Space Sciences Reference Tables

Topical Review Book Company

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EARTH & SPACE SCIENCES REFERENCE TABLES WORKBOOK

The Introduction – Overview, The Chart, Additional Information, and Diagrams – In these sections you will find the essential information about a specific part of the reference table. These areas contain much information, so read each section carefully to achieve full comprehension of the material.

SET 1 – Questions and Answers – Set 1 group of questions will test your understanding of a specific section of the reference table. It is highly recommended that you first read and have a good knowledge of the introduction pages. Once you have mastered this, the correct answer to each question will be apparent. Try all questions in Set 1, and then correct your work by going to the Answers for Set 1, which are located at the end of the section. The explanation should be clear enough to help you understand any mistakes you have made. If not, ask your teacher for more assistance.

SET 2 – Questions – The answers to these questions are provided in a separate answer key. It's "Show Time"; time to prove to yourself and to your teacher that you know the information for this part of the reference chart. You and your teacher will interact to see how well you have done in this area.

All of us at Topical Review Book Company hope that by mastering the Earth & Space Sciences Reference Tables, your understanding of Earth and Space will be more complete and your grades will improve.

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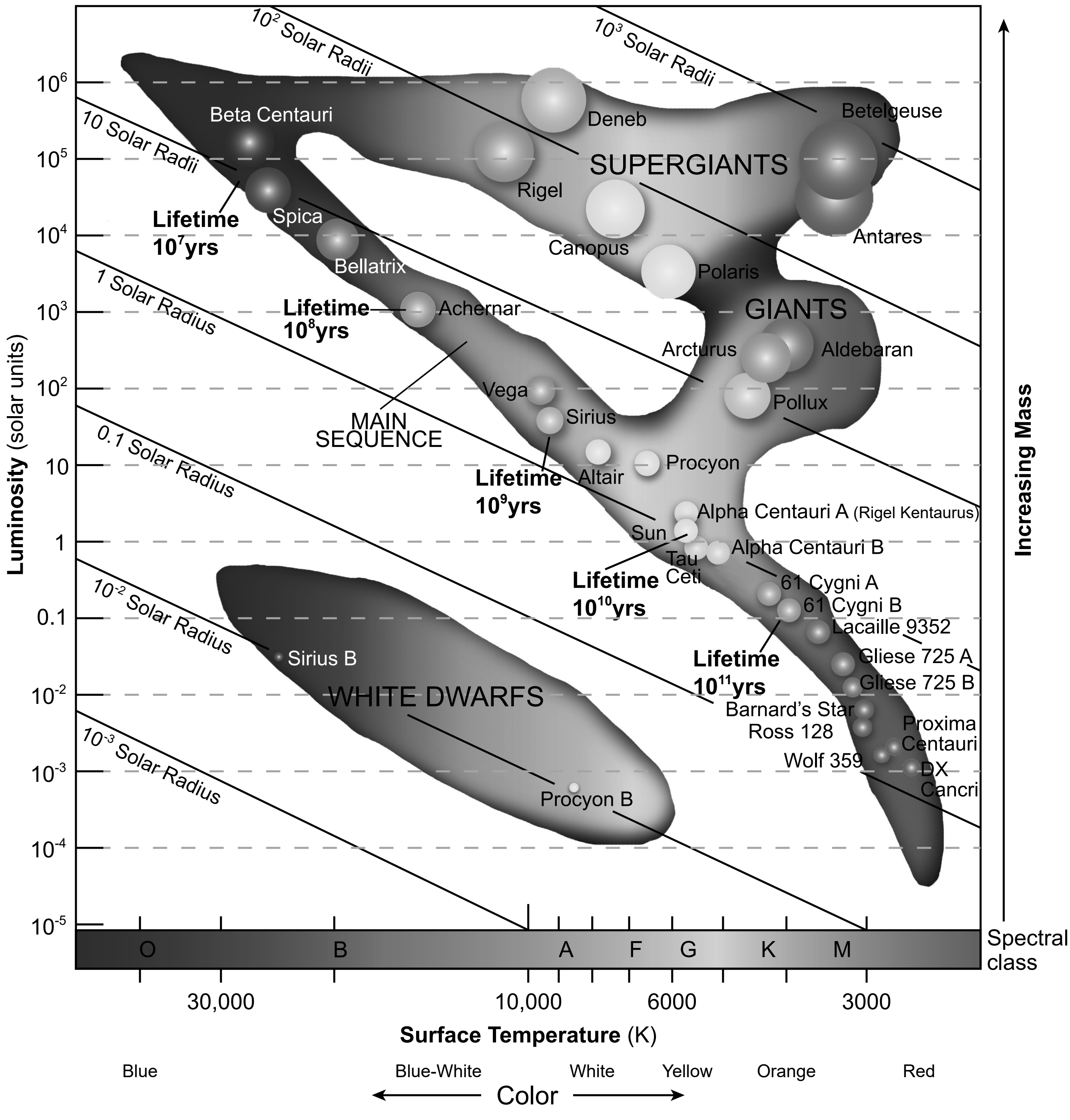
H-R Diagram



Overview:

When the temperature and luminosity (brightness) of stars, all within our Milky Way galaxy, were plotted on a graph, a pattern emerged. Most of the stars fell within a specific region that ran diagonally across the graph, later to be named the "main sequence". Stars off the main sequence fell mainly into three other groups: giants, supergiants, and white dwarfs. Astronomers discovered that this pattern revealed stellar evolution according to the group that the stars were positioned in. The two scientists that independently produced this graph, Hertzsprung and Russell, are credited for making a tremendous contribution to astronomy. Thus, this graph is referred to as the H-R diagram.

The Graph:

The X-axis – This axis has three scales: Surface Temperature, Color and Spectral class. The *surface temperature* of a star is given in Kelvin (K) degrees. The surface temperature of a star determines its *color*. A star that radiates above 30,000 K would be blue, while a star that radiates below 3,000 K would be red. On a clear moonless night, look for the different colors of stars. *Spectral class* is a classification system of seven letters that represent a surface temperature sequence from hotter stars (O) to cooler stars (M). Our Sun is a class G star, having a surface temperature in the range of 5,000 K – 6,000 K. The H-R graph shows that on the main sequence O stars are the hottest but the least common, while the M stars are the coolest but most common.

The Y-axis – The left-side of the *y*-axis is the Luminosity scale. This scale represents the relative brightness of a star compared to our Sun, if that star and our Sun were placed side by side at a given distance from Earth. Our Sun is assigned the luminosity value of 1. Brighter stars have a luminosity value greater than 1, and duller stars have a luminosity value less than 1. On the right side of the *y*-axis is the Increasing Mass scale. The more massive stars are at the top. The luminosity value of a star is mostly based on its size rather than its temperature. For example, Betelgeuse is a massive cool red star but has a high luminosity value (10^5) caused by its tremendous size. This red star is easily observed in the winter constellation Orion.

The Main Sequence Stars – The main sequence stars run diagonally across the graph. When nuclear fusion occurs forming a star, forces (gravity and nuclear) become balanced and the star becomes a main sequence star. Stars spend most of their lives as main sequence stars. Some examples of these stars, as shown on the graph, are Alpha Centauri B, our Sun, Altair, Vega, and Spica.

Lifetime Scale – The lifetime scale values, which appear along the main sequence, represents how long a star would remain as a main sequence star. The more massive a star is, the faster it consumes its fuel, resulting in a shorter lifespan compared to a smaller star. Locate the star 61 Cygni B. This smaller star is shown to have a lifespan of 10^{11} years. Now, locate the star Spica. Being a massive star, its lifetime is far shorter at only 10^7 years.

Solar Radius – The solar radius is a unit used to express the size of stars relative to our Sun, which has a value of 1. A star that falls on the 10 solar radii line, like Spica, has a radius just under ten times that of our Sun. Betelgeuse, a true giant, has a radius 1,000 times that of our Sun.

Supergiant and Giant Stars – When a star’s hydrogen fuel becomes limited, it greatly expands, causing its surface temperature to cool. This repositions the star off the main sequence into the giants or supergiants region. The mass of the star determines whether it becomes a giant or supergiant. The most massive stars become supergiants. All of these stars are now in their intermediate stage of life.

White Dwarfs – White dwarf stars are very dense, smaller, hot stars. Their luminosity is low because of their small size. Over billions of years, they cool and become a cold, inert stellar remnant referred to as a black dwarf. Both Sirius B and Procyon B are white dwarf stars.

Additional Information:

- The Sun's energy is the result of nuclear fusion – an energy producing process. The equation for the fusion reaction of hydrogen is:

$$\underset{\text{(lighter element)}}{\text{Hydrogen}} + \underset{\text{(lighter element)}}{\text{Hydrogen}} \rightarrow \underset{\text{(heavier element)}}{\text{Helium}} + \text{Energy}$$

- Our Sun is estimated to be 4.6 billion years old. Our universe is estimated to be 13.7 billion years old.

Diagrams:

	Temperature		**Luminosity**	
Stars	Hotter	Cooler	Brighter	Dimmer
Procyon B	X			X
Wolf 359		X		X
Spica	X		X	

1. **Characteristics of Stars** – This chart shows the comparison of temperature and luminosity of three stars to our Sun. Massive stars located on the main sequence (Spica) has a greater luminosity and a hotter temperature than our Sun. Smaller stars (i.e., Wolf 359) on the main sequence tend to be cooler with lower luminosity values. Dwarf stars (i.e., Procyon B) tend to be hotter but because of their small size they are dimmer.

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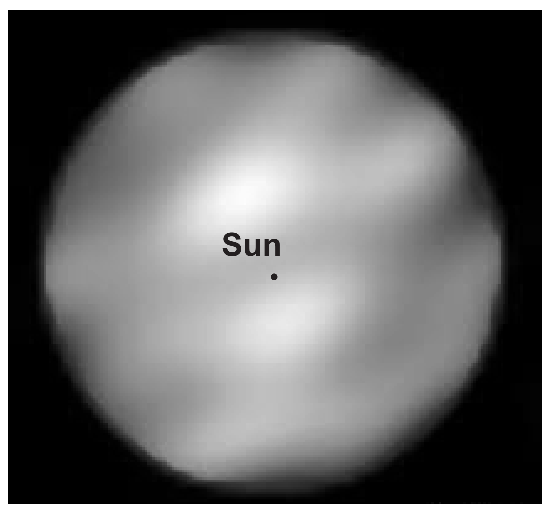
2. **Betelgeuse and our Sun** – Betelgeuse is a late-stage, massive supergiant star. It is close to 1,000 times as large as our Sun. Yet it is relatively young, for large stars use up their fuel faster than smaller stars. In time, this star will supernova, exploding most of its material deep into space. The dot is the relative size of our Sun compared to Betelgeuse.

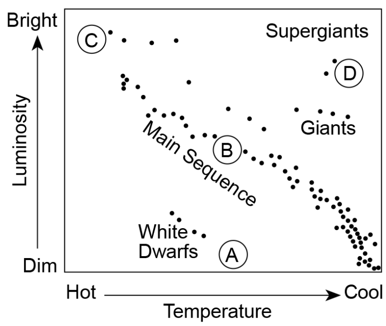


Set 1 — H-R Diagram

1. Which star color indicates the hottest star surface temperature?

   (1) blue (3) yellow
   (2) white (4) red 1 ________

2. The graph represents the brightness and temperature of stars visible from Earth.



   Which location on the graph best represents a star with average brightness and temperature?

   (1) *A* (2) *B* (3) *C* (4) *D* 2 ________

3. Which star is more massive than our Sun, but has a lower surface temperature?

   (1) Procyon B (3) Sirius B
   (2) Aldebaran (4) Alpha Centauri B
   3 ________

4. Which star is hotter and 100,000 times brighter than Earth's Sun?

   (1) Barnard's Star (3) Rigel
   (2) Betelgeuse (4) Antares 4 ________

5. Compared with our Sun, the star Betelgeuse is

   (1) smaller, hotter, and less luminous
   (2) smaller, cooler, and more luminous
   (3) larger, hotter, and less luminous
   (4) larger, cooler, and more luminous
   5 ________

6. Which two stars have the most similar luminosity and temperature?

   (1) Betelgeuse and Barnard's Star
   (2) Rigel and Betelgeuse
   (3) Alpha Centauri A and the Sun
   (4) Sirius B and Procyon B 6 ________

7. Compared to the temperature and luminosity of the star Achernar, the star Sirius B is

   (1) hotter and more luminous
   (2) hotter and less luminous
   (3) cooler and more luminous
   (4) cooler and less luminous 7 ________

8. In nuclear fusion what occurs?

   (1) Lighter elements are converted to heavier elements.
   (2) Lighter elements are converted to even lighter elements.
   (3) Heavier elements are converted to lighter elements.
   (4) Heavier elements chemically combine with lighter elements. 8 ________

9. Betelgeuse and Canopus are both red-giant stars. Give a statement comparing their luminosity and temperature values.

   ____

10. A star located off the main sequence indicates what? ____

   ____

Set 2 — H-R Diagram

11. Compared to the surface temperature and luminosity of massive stars in the Main Sequence, the smaller stars in the Main Sequence are

(1) hotter and less luminous
(2) hotter and more luminous
(3) cooler and less luminous
(4) cooler and more luminous 11 ______

12. The star Phecda has a surface temperature of approximately 9500 K and a luminosity of 10^2. Of the following stars, which has nearly the same values as Phecda?

(1) Sirius B (3) Vega
(2) Rigel (4) Pollux 12 ______

13. To an observer on Earth, the Sun appears brighter than the star Rigel because the Sun is

(1) hotter than Rigel
(2) more luminous than Rigel
(3) closer than Rigel
(4) larger than Rigel 13 ______

14. Which star is hotter, but less luminous, than Altar?

(1) Deneb (3) Procyon B
(2) Aldebaran (4) Pollux 14 ______

15. The Sun revolves around the center of

(1) Polaris
(2) Aldebaran
(3) solar system
(4) the Milky Way Galaxy 15 ______

16. A newly discovered star has a surface temperature of 7400 K and a luminosity of 10^5. The classification of this star would be

(1) white dwarf (3) giant
(2) main sequence (4) supergiant
16 ______

17. The inferred temperature at the boundary of the inner and outer core is 5500 K. Which star radiates close to this temperature and has a solar radius of 1?

(1) Canopus (3) Tau Ceti
(2) Polaris (4) Procyon 17 ______

18. Which star is projected to continue its nuclear reaction for the longest duration?

(1) our Sun (3) Ross 128
(2) Spica (4) Achernar 18 ______

19. Which object in space emits light because it releases energy produced by nuclear fusion?

(1) Earth's Moon (3) Venus
(2) Halley's comet (4) Polaris 19 ______

20. In about 500 million years Vega is expected to enter its intermediate stage and become a giant star. When this occurs, which of the following values would be expected for Vega?

(1) luminosity of 10^2, temperature 9,000 K, solar radii 3
(2) luminosity of 10^3, temperature 4,000 K, solar radii 20
(3) luminosity of 0.1, temperature 12,000 K, solar radius 10^{-2}
(4) luminosity of 10^5, temperature 4,000 K, solar radius 10^3 20 ______

21. Compared to the luminosity and surface temperature of red main sequence stars, blue supergiants are

(1) less luminous and have a lower surface temperature
(2) less luminous and have a higher surface temperature
(3) more luminous and have a lower surface temperature
(4) more luminous and have a higher surface temperature 21______

22. Which table includes data that are characteristic of the surface temperature and luminosity of some white dwarf stars?

(1)

Surface Temperature	5000 K
Luminosity	100

(2)

Surface Temperature	5000 K
Luminosity	0.001

(3)

Surface Temperature	10,000 K
Luminosity	100

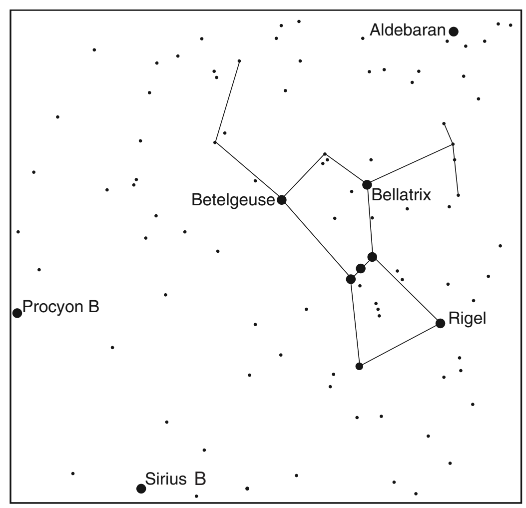
(4)

Surface Temperature	10,000 K
Luminosity	0.001

22______

23. Explain why a giant star that is cooler than our Sun, similar to Aldebaran, has a greater luminosity than our Sun. ____

The star chart shows part of the winter sky visible from New York State. Some of the brighter stars are labeled and the constellation Orion is outlined.



24. *a*) Identify the color of the star Bellatrix, which has a surface temperature of approximately 21,000 K.

____

b) Which star on the chart would be classified the youngest?

____

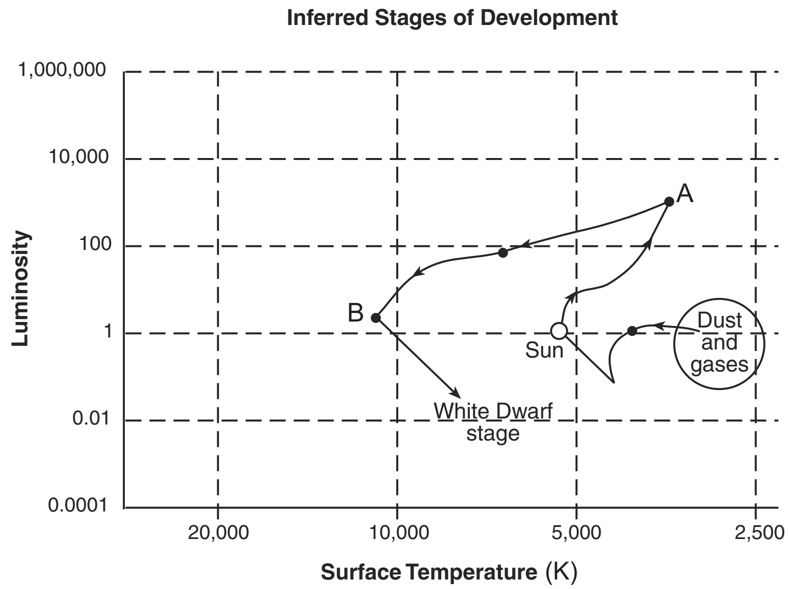
c) In the accompanying chart, list the stars, other than Bellatrix, found on the chart in order of decreasing luminosity. Rigel, the most luminous star, has been listed.

Most luminous	(1)	Rigel
	(2)	____________
	(3)	____________
	(4)	____________
Least luminous	(5)	____________

25. Give a statement on the relationship between temperature and luminosity of the main sequence stars.

____

Base your answers to question 26 on the on the accompanying graph. The graph shows the inferred stages of development of the Sun, showing luminosity and surface temperature at various stages.



26. *a*) Describe the changes in luminosity of the Sun that will occur from its current Main Sequence stage to its final White Dwarf stage.

____

b) Identify the process that produces the Sun's energy. ______________________

c) Why does the Sun's luminosity increases and its temperature decreases at position *A*?

____

d) At position *A*, what color star would be observed? ______________________

e) Name a star that is currently at the Sun's final predicted stage of development.

____

27. Identify two stars that are at the same life-cycle stage as the Vega but have a greater luminosity.

1)______________________ 2)______________________

28. Both Sirius B and Procyon B are classified as white dwarfs. Describe one characteristic of the star Sirius B that causes it to have a greater luminosity than Procyon B. ______________________

29. Describe how the relative surface temperature and the relative luminosity of Aldebaran would change when it collapses and becomes a white dwarf.

____

30. List the following astronomical features, in order of relative size, from smallest to largest.

Sun	Smallest	______________
Deneb		______________
Milky Way Galaxy		______________
Bellatrix		______________
Proxima Centauri		______________
Pollux	Largest	______________

H-R Diagram

Set 1 – Answers

1. 1 In the H-R Diagram, go to the Temperature axis. Blue stars have the hottest surface temperatures, over 30,000 K.

2. 2 An average star would be located on the main sequence and have the same luminosity and temperature as our Sun. Locate our Sun on the diagram. Location *B* is close to where our Sun is positioned.

3. 2 On the H-R Diagram, Aldebaran is classified as a giant star, which is more massive than our Sun. Aldebaran surface temperature is close to 4,000 K, which is cooler than our Sun.

4. 3 Locate Rigel on the H-R Diagram. As shown, the luminosity of this star is (10^5) greater than that of our Sun. Its temperature is around 10,000 K, while the Sun's temperature is just under 6,000 K.

5. 4 Betelgeuse has a temperature around 3,200 K, which is cooler than our Sun. It has a greater luminosity than our Sun because it is a supergiant star.

6. 3 Alpha Centauri A and the Sun are next to each other.

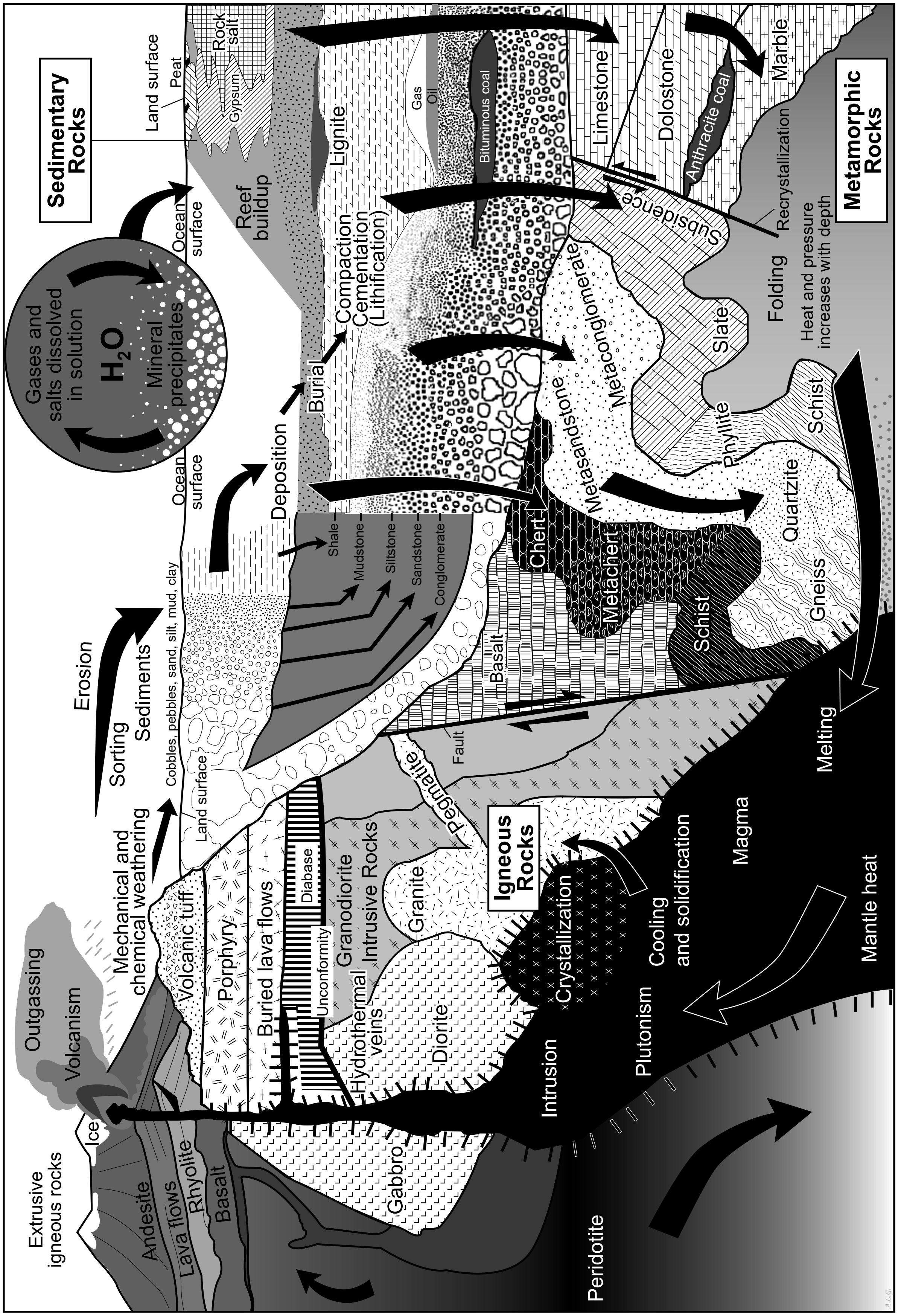
7. 2 Sirius B is positioned lower on the Luminosity scale than Achenar. The temperature of Sirius B is hotter than that of Achenar, as shown by the surface temperature scale.

8. 1 By the process of nuclear fusion, lighter nuclei are joined to produce a heavier nucleus, while releasing massive amounts of energy.

9. Betelgeuse has a slightly higher luminosity; Canopus has a higher temperature.

10. In stellar evolution, when a star is off the main sequence it may indicate that:
    a) it is in its dying stage.
    b) its fuel is running out.
    c) it is expanding, causing its temperature to cool.
    d) it has collapsed and is a white dwarf.
    e) it has entered the intermediate or late stage of its existence.

Rock Cycle Infographic



Rock Cycle Infographic

Overview:

All rocks can be classified as igneous, metamorphic or sedimentary. As permanent as rocks appear, eventually geologic forces act on them, causing changes. These changes may alter the rock to be reclassified into a different family of rocks. Even rocks that have been melted back within the mantle, forming magma, may one day surface as lava, solidifying only to be exposed again to the forces of the "Rock Cycle."

Rock Families:

This chart is packed with information on the different processes and environments that create, alter and reform new rocks. The chart has three main sections, based on the different families of rocks. First, let's review each rock family.

Igneous Rocks – All igneous rocks started as molten rock. As the magma or lava cools, it undergoes solidification, changing the molten rock to a solid. The crystallization of magma produces intrusive igneous rocks, usually with visible crystals. Lava produces extrusive igneous rocks that cool relatively rapidly, producing small or no visible crystals. The rate of cooling and the composition of the magma or lava will create different rocks, but because they originated from molten material, all are igneous rocks.

Sedimentary Rocks – Rocks at or near the surface will undergo weathering, producing smaller sediments. These smaller rocks can be transported mainly by wind and water. Many sediments are eventually deposited in a quiet body of water. These buried sediments become compacted and undergo cementation, forming sedimentary rocks. The accumulation of dead organic substances can be compressed, producing a rock in this family. Minerals that are precipitated (released) from a solution can accumulate forming a sedimentary rock. This usually occurs when a shallow sea undergoes evaporation.

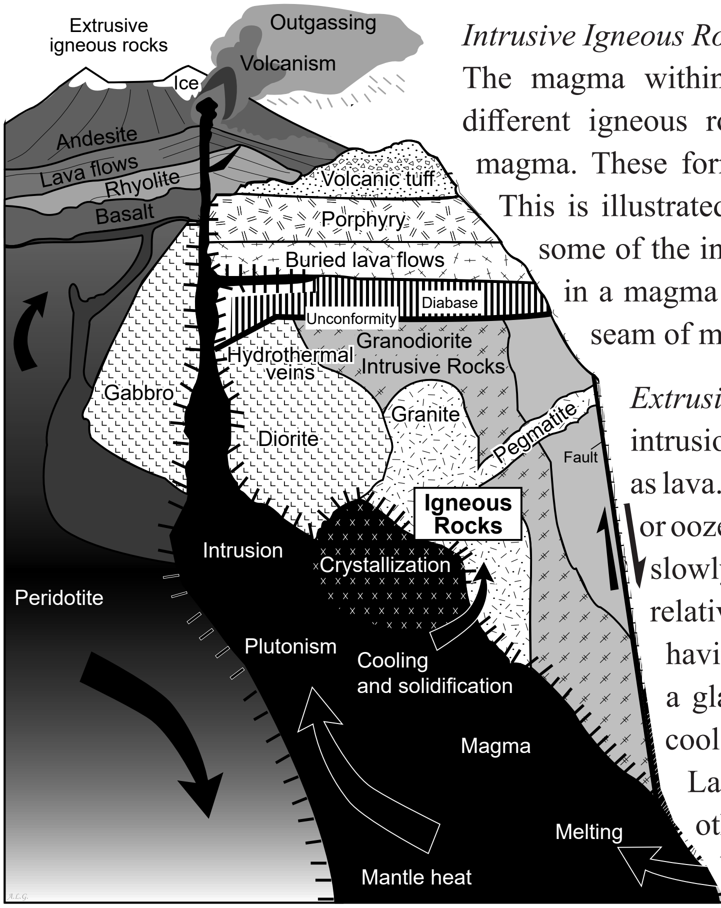
Metamorphic Rocks – Heat and/or pressure applied to rocks may change them into metamorphic rocks, if they don't melt. When there is enough heat or pressure, the minerals within a rock can be altered, producing a new rock classified as a metamorphic rock. Plate tectonics is the major force that produces the needed heat/pressure of metamorphism. Mountain ranges that form from colliding plates will have a high percentage of metamorphic rocks.

The Chart:

To help understanding this detailed chart, I've elected to separate the chart into each rock family. Remember though that in the rock cycle, forces producing a rock in one family may also create a rock in another family.

Igneous Rock Section:

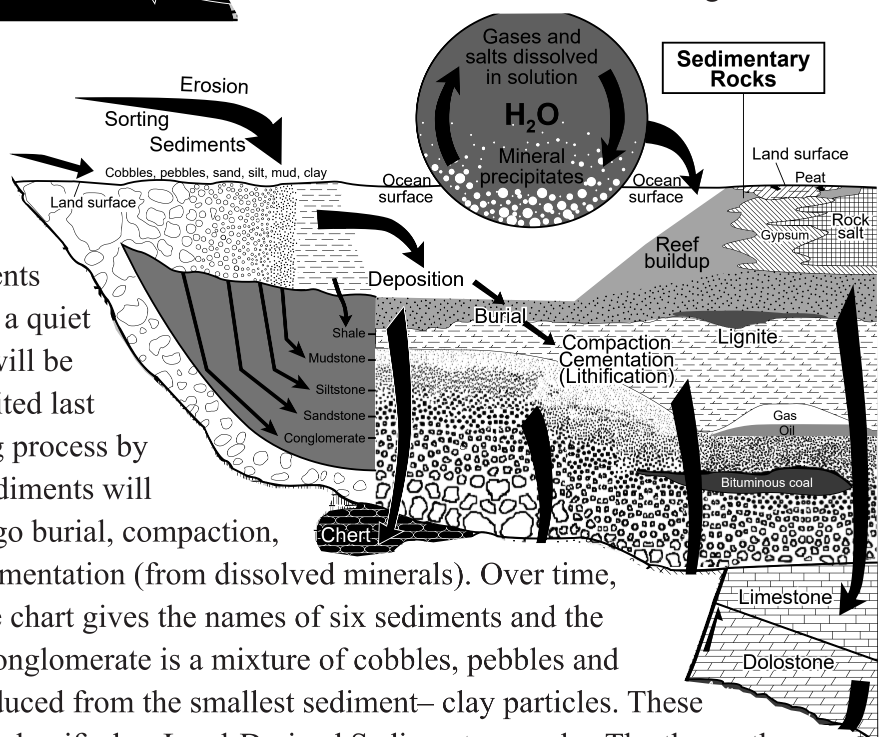
The igneous rocks were the first rocks ever formed. This occurred as melted molten rock cooled and solidified. Magma produces intrusive rocks, while lava produces extrusive igneous rocks.



Intrusive Igneous Rocks – A magma chamber is a large pool of magma. The magma within cools very slowly and eventually may form different igneous rocks based on the mineral composition of the magma. These formed intrusive rocks will exhibit visible crystals. This is illustrated around the word crystallization. Above this are some of the intrusive rocks (granite, diorite, etc.) that may form in a magma chamber. The diagrammed igneous intrusion is a seam of magma that cuts through existing rocks.

Extrusive Igneous Rocks – As shown in the diagram, intrusions bring magma to the surface, and now it's known as lava. Lava can be violently ejected by volcanic eruptions or ooze out of a deep crustal opening producing a lava flow, slowly spreading outward. In all cases, lava cools relatively quickly, either producing very small crystals, having a fine texture, or lacking any crystals, having a glassy texture. The composition of the lava and its cooling rate can form different extrusive igneous rocks. Later volcanic eruptions can cover lava flows and other extrusive rock layers. The diagram shows two buried lava flows and four extrusive igneous rocks.

Sedimentary Rock Section:



Mechanical (physical) and chemical weathering forces act on rocks at or near the surface. These forces break down solid bedrock to smaller sediments that can be eroded away. If they enter a quiet body of water, the largest sediments will be deposited first and the smallest deposited last and farthest out. This creates a sorting process by size and density. The different size sediments will produce different rocks as they undergo burial, compaction, (from the weight above them), and cementation (from dissolved minerals). Over time, different sedimentary rocks form. The chart gives the names of six sediments and the resulting rocks they form. The rock conglomerate is a mixture of cobbles, pebbles and other smaller sediments. Shale is produced from the smallest sediment– clay particles. These six rocks formed from sediments are classified as Land-Derived Sedimentary rocks. The three other classifications of sedimentary rocks are the following:

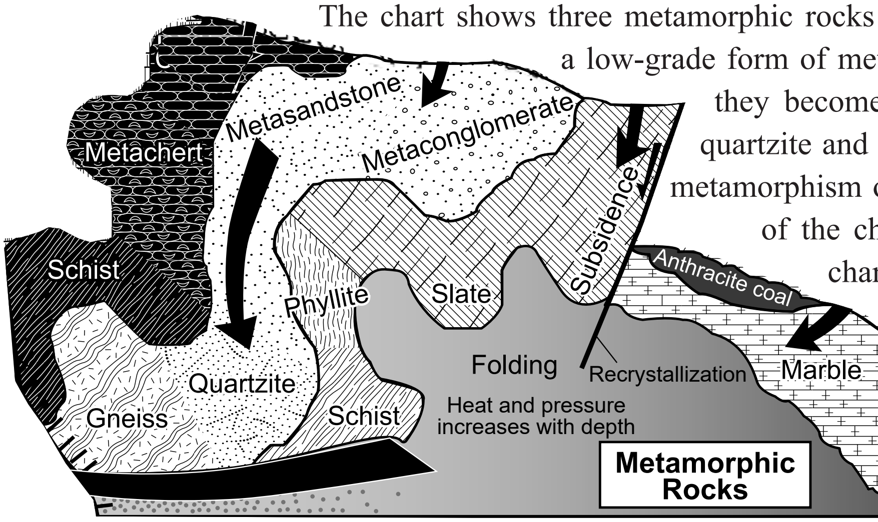
Mineral Sedimentary Rocks – Concentrated dissolved minerals can be released or precipitated out of a solution and accumulate on the bottom of the water source. When these "released" minerals become cemented, it becomes a sedimentary rock such as gypsum and rock salt.

Organic Sedimentary Rocks – Dead organic material can accumulate in bogs or swamps. Over time this material gets compressed to form first peat, then lignite and then sedimentary bituminous coal–all are different grades of coal. At the upper right side of the chart shows "Reef buildup." Coral is a type of organic biochemical rock produced by coral polyps secreting layers of calcium carbonate. Oil and natural gas are produced from the decay of organic matter that lived millions of years ago. Sedimentary layers trapped and now contain these resources.

Chemically Formed Sedimentary Rocks – Limestone and dolostone are chemically (or biochemically) formed sedimentary rocks. Both contain the mineral calcite, which reacts to an acid.

Metamorphic Rock Section:

Rocks can be subjected to heat and pressure from Earth's forces. If these forces do not melt the rocks, they can alter them, changing the original rock into a metamorphic rock. Thus, all metamorphic rocks are made from preexisting rocks. The metamorphism of limestone and/or dolostone produces marble. The chart shows three metamorphic rocks that have the prefix meta, indicating a low-grade form of metamorphism. With more heat/pressure they become true metamorphic rocks, producing quartzite and gneiss. Locate slate. It is a low-grade metamorphism of shale. Following this curvy section of the chart, under more heat/pressure it will change to phyllite and then to schist. The sedimentary coal—bituminous coal—can be changed into metamorphic anthracite coal. This is the preferred coal for use.



***Types of Metamorphism*:**

Contact Metamorphism – The heat of an igneous intrusion can cause the surrounding rocks to metamorphose. This is called contact metamorphism. In the igneous section, this is diagrammed by hash-marks on the edges of the intrusion as it comes into contact with preexisting rocks.

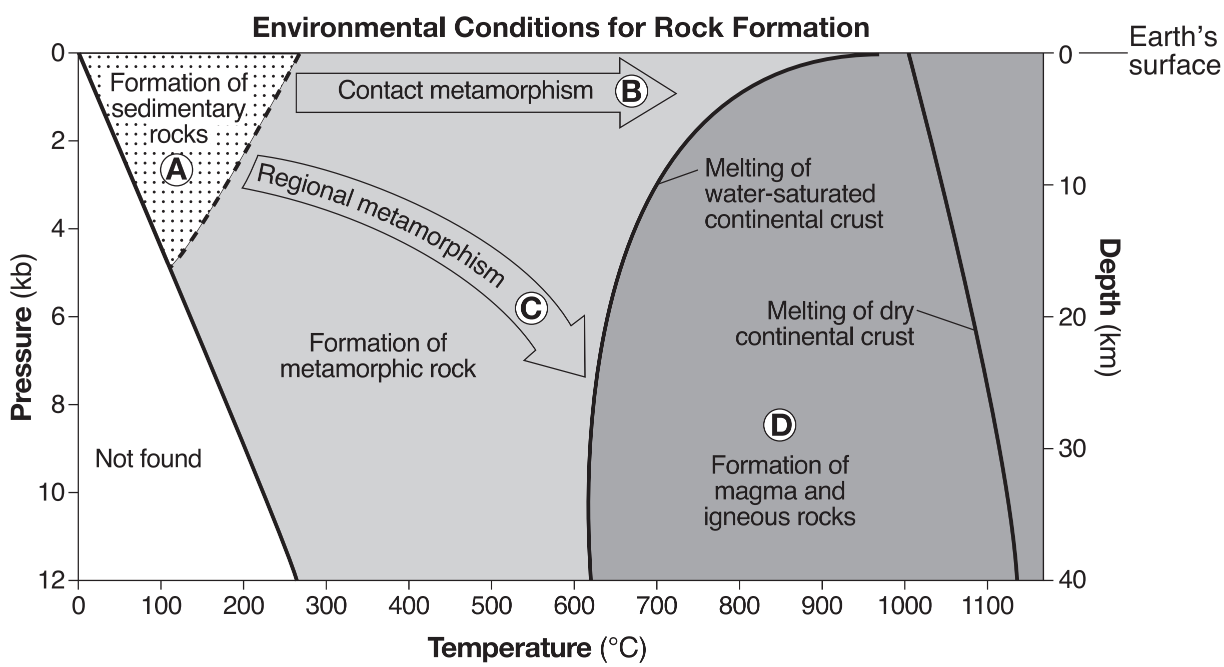
Regional Metamorphism – This is a very large area that has undergone metamorphism. Plate collisions produces regional metamorphism, forming folded mountains.

Remember, each family of rocks has its unique processes to produce them: igneous rocks → molten rock that solidifies; metamorphic rocks → rocks altered by heat and/or pressure; sedimentary rocks → the compaction and cementation (lithification) of sediments along with organic material and chemicals precipitated out of a solution.

Additional Information:

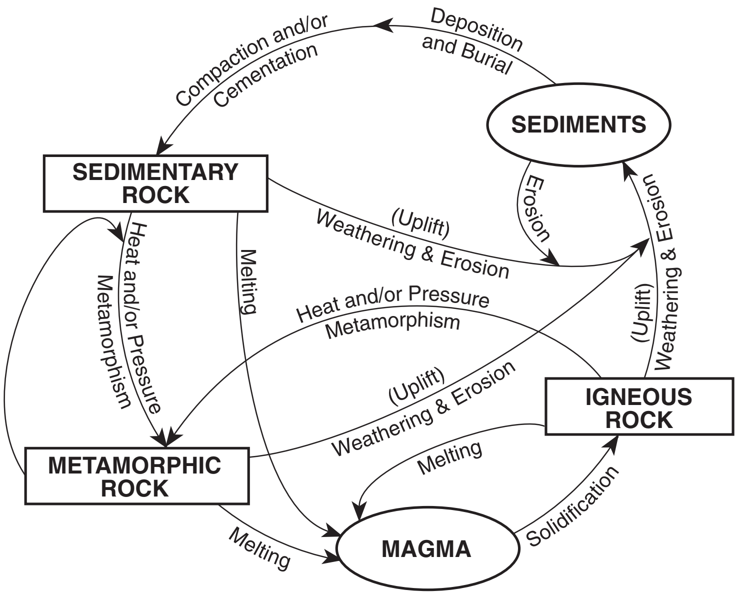
- Sedimentary rocks are the most common rocks found on the Earth's surface.
- The evidence of fossils indicates a sedimentary rock.
- On the Igneous diagram is the term unconformity. This is an area of missing layer(s), making a time gap in the geologic history of the area. It was caused by uplifted layers that were eroded away. Then, sometime later the land subsided (sank) and new layers were deposited over the eroded layer.
- Pressure and heat of metamorphism can alter the minerals. This is known as recrystallization. (See lower section of the Metamorphic chart.)
- An extrusion will cause contact metamorphism to the layer it rests on. Any layer that develops on top of the extrusion will not show contact metamorphism because the extrusion has cooled to a solid.
- Mount Rushmore was carved from mostly granite that solidified deep in a magma chamber and was later uplifted, exposed to the Earth's surface.

Diagrams:



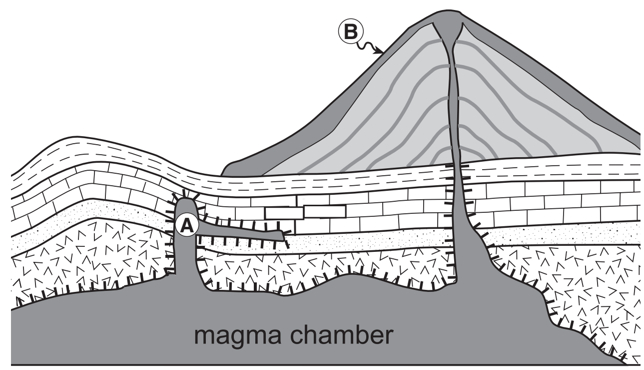
1. **Environmental Conditions for Rock Formation** – The graph shows the temperature, pressure, and depth environments for the formation of the three major rock families. Letters *A* through *D* identify different environmental conditions for rock formation. Sedimentary rocks form on or near the surface, while metamorphic rocks need much heat/pressure, but the temperature cannot reach the rock's melting point. Magma exists at the highest temperature and pressure; upon cooling, igneous rocks form.

2. **Rock Cycle in Earth's Crust** – The outside circle shows the processes and steps that change rocks from one family to another. This chart also shows many other paths represented by inner arrows.



Igneous Rocks

3. **Igneous Environments** – A magma chamber is an underground pool of liquid rock. If the outer part of this chamber (A) cools enough to solidify, the resulting intrusive igneous rocks will have a coarse texture exhibiting large interlocking crystals. If the magma surfaces, the lava (B) will cool quickly, producing an extrusive igneous rock with a fine, glassy texture.



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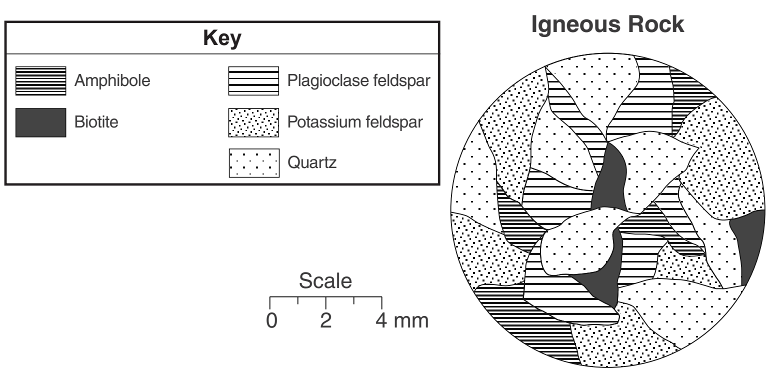
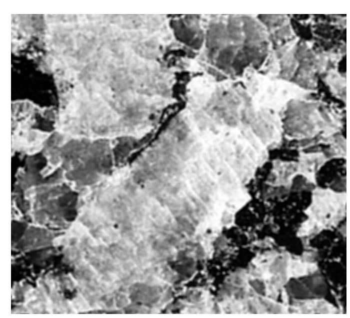


(1)



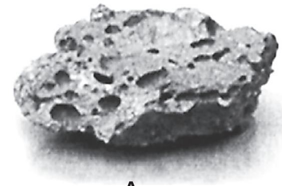
(Actual size)

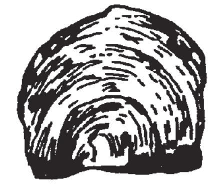
(2)

Intrusive Igneous Rock – Figure 1 shows the magnified drawing of minerals found in an intrusive igneous rock. Based on the size of its intergrown crystals, the environment of formation must have been intrusive (plutonic). Figure 2 is an actual photograph of such an intrusive igneous rock that cooled slowly, growing large crystals.

5. **Extrusive Igneous Rocks** – Rock *A* has gas pockets, showing it cooled rapidly, trapping air as lava was ejected from a volcano.

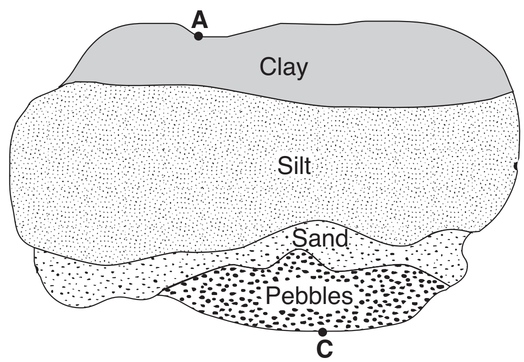
Rock *B* shows a glassy texture, making it non-crystalline. A lava flow on the Earth's surface cooled quickly, producing this texture.





Sedimentary Rocks

6. **Sediments to Rocks** – This diagram represents the deposition of sediments when a river enters a lake. Over years and with compaction and/or cementation, these sediments of different sizes produce different sedimentary rocks. Clay becomes shale, silt becomes siltstone, sand becomes sandstone and a mixture of pebbles and smaller sediments produce the sedimentary rock known as conglomerate.



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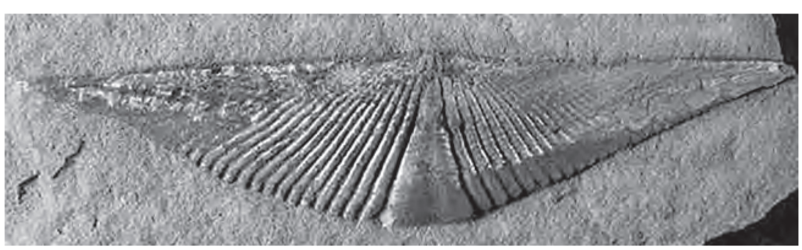
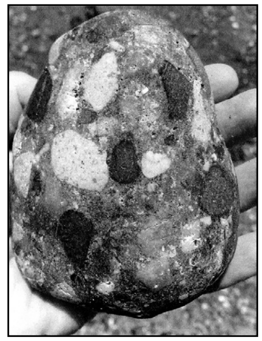
7. **Identification of a Sedimentary Rock** – The diagram represents a sedimentary rock composed of cemented pebbles and sand. This rock is a conglomerate because it contains many sized sediments. Remember, inorganic land-derived sedimentary rocks are based on grain size, not composition.

8.



Sedimentary Rocks and Fossils – Most sedimentary rocks were formed under water. When marine organisms die, some are preserved in the marine sediments and fossilized as the sediments become cemented and/or compacted, changing into a sedimentary rock. A great clue that a rock is sedimentary is the presence of fossils – like this Paleozoic brachiopod.

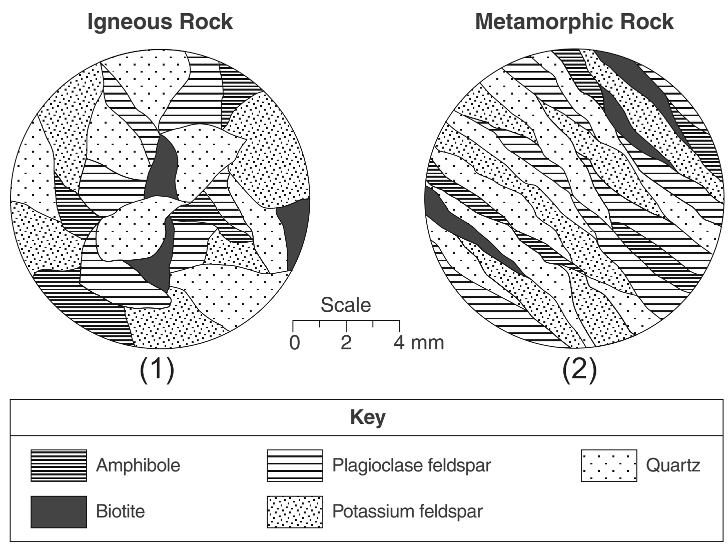
9. **Sedimentary to Metamorphic –** This conglomerate rock (A) was subjected to Earth's forces that increased the temperature and pressure enough to metamorphize the sedimentary rock to a metaconglomerate (B).



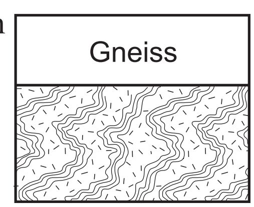
Rock A

Rock B

10. **Mineral Alignment** – Figure 1 represents the igneous rock granite, having interlocking crystals. When it undergoes metamorphism, the increase of heat and pressure causes minerals to undergo recrystallization and become aligned (figure 2).

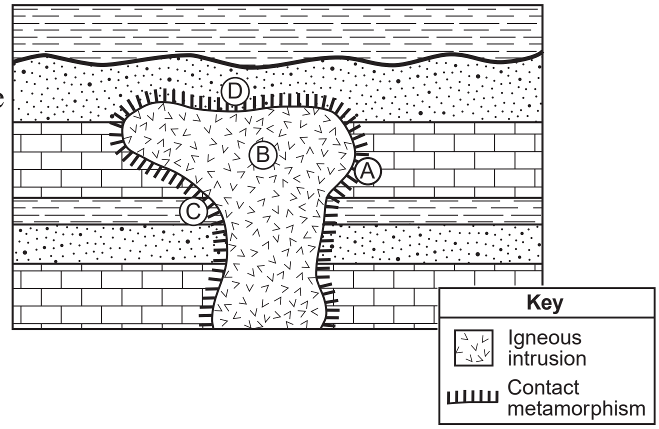


11. **Gneiss** – Gneiss is a metamorphic rock that formed from a preexisting rock that had been subjected to great pressure and heat due to regional metamorphism. These conditions caused the minerals to segregate into "wavy" bands.



Banding

12. **Contact Metamorphism** – Letter *B* represents an intrusion of magma that solidified into an igneous rock. When the magma intruded the rock layers, the heat of the magma caused contact metamorphism to the previous existing rocks. In the contact area, letter *D*, sandstone, is now quartzite; letter *C*, shale, is now slate; and letter *A*, limestone, has been metamorphosed to marble.



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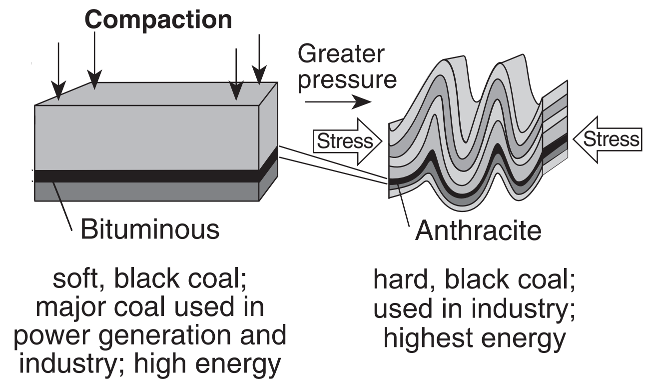
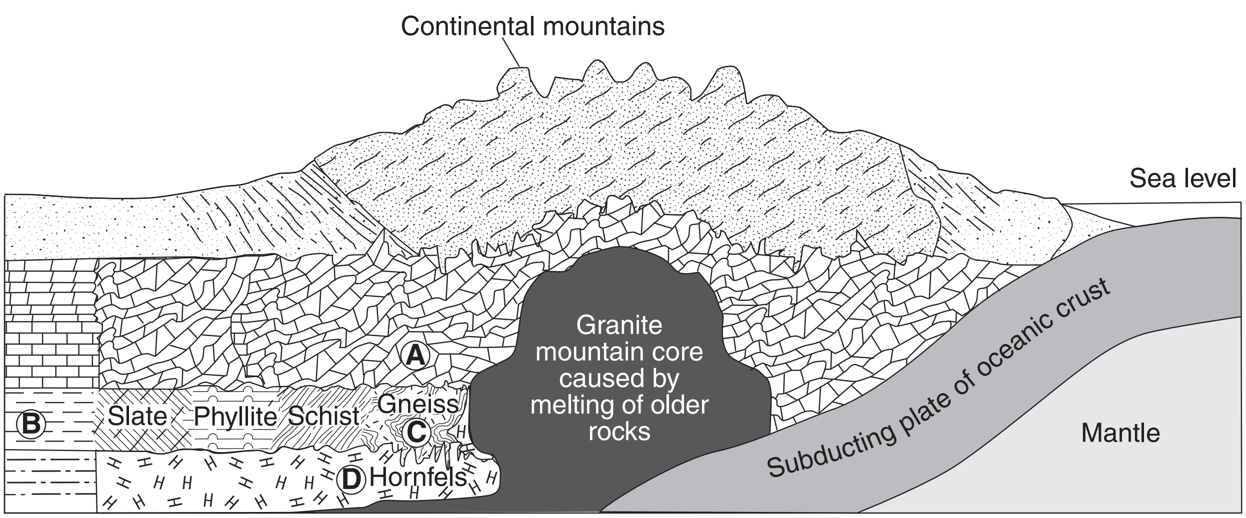
13. **Sedimentary to Metamorphic** – Bituminous coal is a sedimentary rock formed by compaction of organic matter. If this rock layer is subjected to an increase of heat and pressure the soft bituminous coal changes into hard anthracite coal. This metamorphic coal is the highest grade of coal.





14. **Regional Metamorphism** – Regional metamorphism is a type of metamorphism that affects a large area by the force of plate tectonics. The above model details where and how different metamorphic rocks (*A*, *C*, *D*) are made by the build up of heat and pressure as an oceanic plate moves into a continental plate.

Set 1 — Rock Cycle Infographic

1. Rocks are classified as igneous, sedimentary, or metamorphic based primarily on their

   (1) texture
   (2) crystal or grain size
   (3) method of formation
   (4) mineral composition 1______

2. When granite melts and then solidifies, it becomes

   (1) a sedimentary rock
   (2) an igneous rock
   (3) a metamorphic rock
   (4) sediments 2______

3. Which statement about the rock cycle is *not* true?

   (1) Cementation is a process that leads to sedimentary rocks.
   (2) When heat is applied to a rock and it melts, it may form a metamorphic rock.
   (3) A sedimentary rock in the future may change into another type of sedimentary rock.
   (4) Solidification is always needed to form an igneous rock. 3______

4. The burial process involving sedimentary rocks is usually

   (1) deep within the Earth.
   (2) at the surface of the Earth.
   (3) within a water environment.
   (4) at an ocean ridge. 4______

5. The solidification of magma produces

   (1) igneous and metamorphic rocks.
   (2) sedimentary rocks and igneous rocks.
   (3) only igneous rocks.
   (4) only metamorphic rocks. 5______

6. Which statement about a metamorphic rock is not supported by the rock cycle?

   (1) A metamorphic rock may become sediments.
   (2) Metamorphic rocks may one day undergo melting.
   (3) A metamorphic rock has undergone cementation.
   (4) A metamorphic rock may eventually become another type of metamorphic rock. 6______

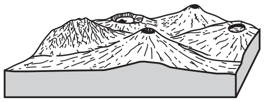
7. A primary difference between sedimentary rocks and nonsedimentary rocks is that

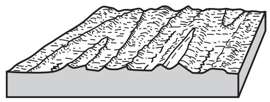
   (1) nonsedimentary rocks contain an abundance of fossils
   (2) nonsedimentary rocks originate in regions of great heat and/or pressure
   (3) sedimentary rocks usually make up most mountains
   (4) sedimentary rocks are formed at plate boundaries 7______

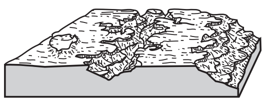
8. Which rock has once melted deep inside the Earth, and slowly, over time its temperature dropped below its melting point?

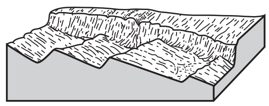
   (1) siltstone (3) peridotite
   (2) schist (4) slate 8______

9. Which diagram represents a landscape where fine-grained igneous bedrock is most likely to be found?


(1)

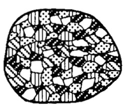

(3)

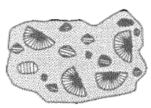

(2)

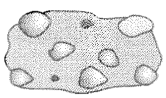

(4)

9______

10. Which diagram best represents a sample of an igneous rock?

(1) 

(3) 

(2) 

(4) 

10 ______

11. Most rock salt is formed by the

(1) heating of previously existing bedrock
(2) cooling and solidification of lava
(3) compaction and cementation of shells and skeletal remains
(4) gypsum 11 ______

12. Which sedimentary rock may form as a result of biologic processes?

(1) shale (3) fossil limestone
(2) siltstone (4) breccia 12______

13. Andesite is a type of rock that forms from the process of

(1) solidification deep within the Earth
(2) solidification close to the Earth's surface
(3) erosion of sediments than became cemented together
(4) being subjected to much heat and pressure without melting 13______

14. Which rock was subjected to intense heat and pressure but did not solidify from magma?

(1) phyllite (3) gabbro
(2) porphyry (4) rhyolite 14______

15. A large exposed formation of gabbro was primarily formed by
(1) metamorphism of layered sandstone
(2) solidification of magma
(3) compaction of precipitated gypsum
(4) cementation of sediments

15______

16. Most sedimentary rocks were formed by

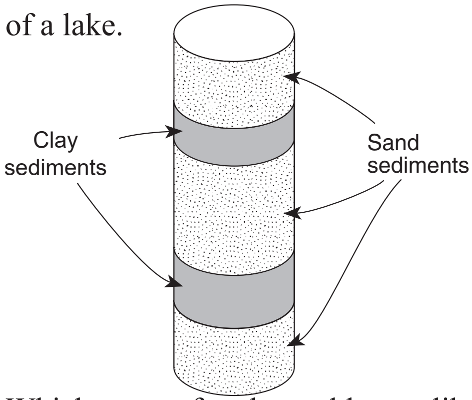
(1) volcanic eruptions and crystallization
(2) compaction and/or cementation
(3) heat and pressure
(4) melting and/or solidification 16______

17. Which type of rock most likely contains fossils?

(1) volcanic tuff (3) schist
(2) gabbro (4) shale 17______

Set 2 — Rock Cycle Infographic

18. The diagram below shows a drill core of sediment that was taken from the bottom of a lake.



Which types of rock would most likely form from compaction and cementation of these sediments?

(1) conglomerate and siltstone
(2) sandstone and shale
(3) shale and bituminous coal
(4) shale and rock salt 18_____

19. Which statement about an igneous rock is not supported by the rock cycle?

(1) All igneous rocks eventually become sedimentary rocks.
(2) An igneous rock may be remelted and solidified into another type of igneous rock.
(3) All igneous rocks must have been a liquid at one time.
(4) An igneous rock can undergo metamorphism. 19_____

20. Wavy bands of light and dark minerals visible in gneiss bedrock probably formed from the

(1) cementing together of individual mineral grains
(2) cooling and crystallization of magma
(3) evaporation of an ancient ocean
(4) heat and pressure during metamorphism 20_____

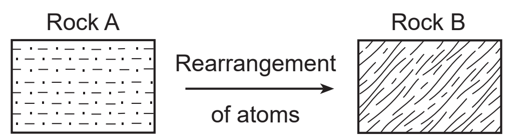
21. The precipitation of the mineral halite would form a layer of

(1) limestone (3) coal
(2) rock salt (4) dolostone 21_____

22. A mixture of rounded pebbles and sand was deposited in a river. Over time, these sediments were compacted and cemented together to form the sedimentary rock

(1) conglomerate (3) megaconglomerate
(2) sandstone (4) shale 22_____

23. The diagram below represents rock *A* changing into rock *B*.



Which process causes rock *A* to change into rock *B*?

(1) melting (3) precipitation
(2) solidification (4) metamorphism
23_____

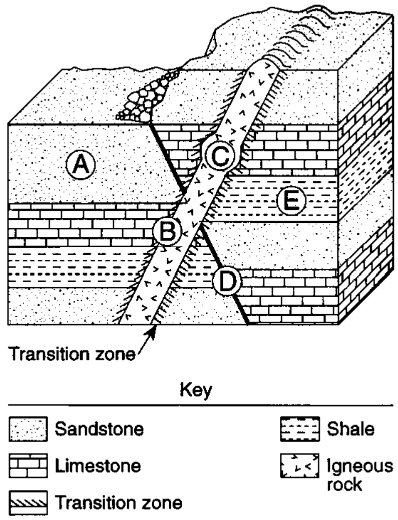
24. Which metamorphic rock is composed mostly of the same minerals as sandstone?

(1) gneiss (3) quartzite
(2) marble (4) schist 24_____

25. Which rock would most likely be produced by the metamorphism of limestone and dolomite?

(1) quartzite (3) marble
(2) slate (4) gneiss 25_____

26. The diagram below shows a portion of the Earth's crust. Letters *A*, *B*, *C*, and *D* indicate different types of rock.



At which location is metamorphic rock most likely to be found?

(1) *A* (3) *C*
(2) *B* (4) *D* 26_____

27. Which rock was organically formed and sometimes contains fossilized plant impressions?

(1) bituminous coal (3) shale
(2) rock salt (4) mudstone
27_____

28. Which rock was made from the smallest sediment?

(1) sandstone (3) shale
(2) mudstone (4) siltstone 28_____

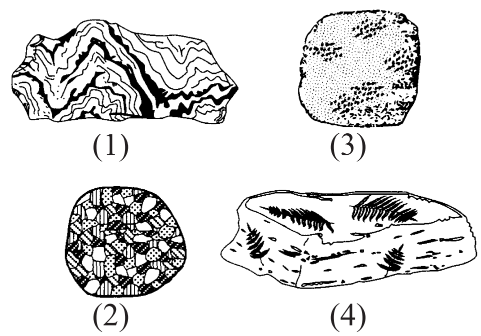
29. Which form of organic matter burns the cleanest and has the highest BTU value —a measurement of heat energy?

(1) anthracite coal (3) lignite
(2) bituminous coal (4) peat 29_____

30. Of the following pairs of sedimentary rocks, which choice contains an inorganic and an organic rock?

(1) sandstone and gypsum
(2) sandstone and shale
(3) shale and reef
(4) shale and siltstone 30_____

31. Which rock sample is most likely metamorphic rock?



31_____

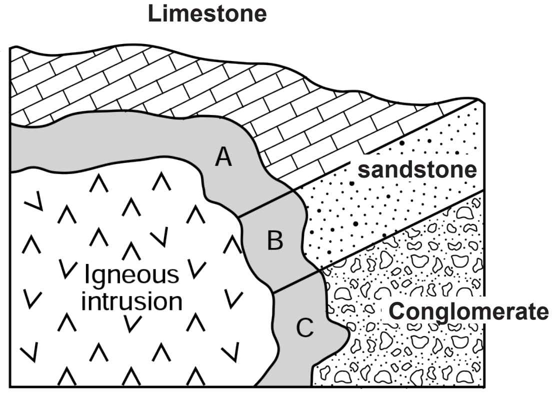
32. The photograph shows conglomerate composed of pebbles cemented together with calcite.

Compared to the ages of the calcite cement and the conglomerate, the relative age of the pebbles is

(1) younger than both the calcite cement and the conglomerate
(2) younger than the calcite cement, but the same age as the conglomerate
(3) older than both the calcite cement and the conglomerate
(4) older than the calcite cement, but the same age as the conglomerate

32_____

33. The cross section represents an igneous intrusion into sedimentary bedrock layers. Letters *A*, *B*, and *C* identify different rocks within the shaded zone of contact metamorphism.

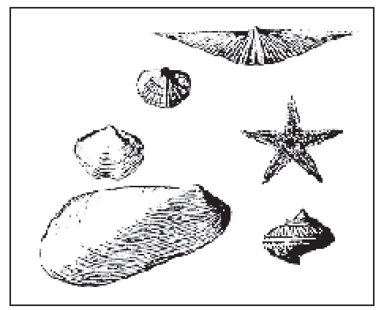


Which metamorphic rocks are most likely formed in zones *A*, *B*, and *C*?

(1) *A* = marble, *B* = gneiss, *C* = schist
(2) *A* = marble, *B* = quartzite, *C* = metaconglomerate
(3) *A* = metaconglomerate, *B* = quartzite, *C* = marble
(4) *A* = metaconglomerate, *B* = schist, *C* = gneiss

33_______

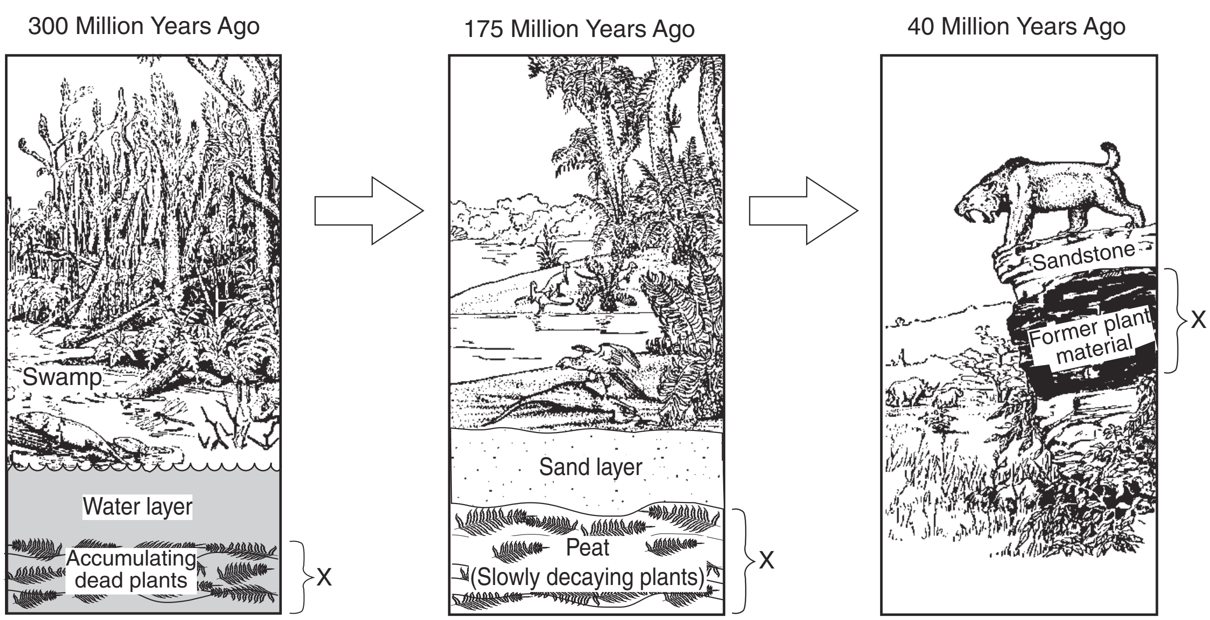
34. The accompanying diagram represents the fossils found in a bedrock formation located in central New York State. In which type of rock were the fossils most likely found?



(1) sedimentary rock that formed in an ocean environment
(2) sedimentary rock that formed in a land environment
(3) igneous rock that formed in an ocean environment
(4) igneous rock that formed in a land environment

34 ______

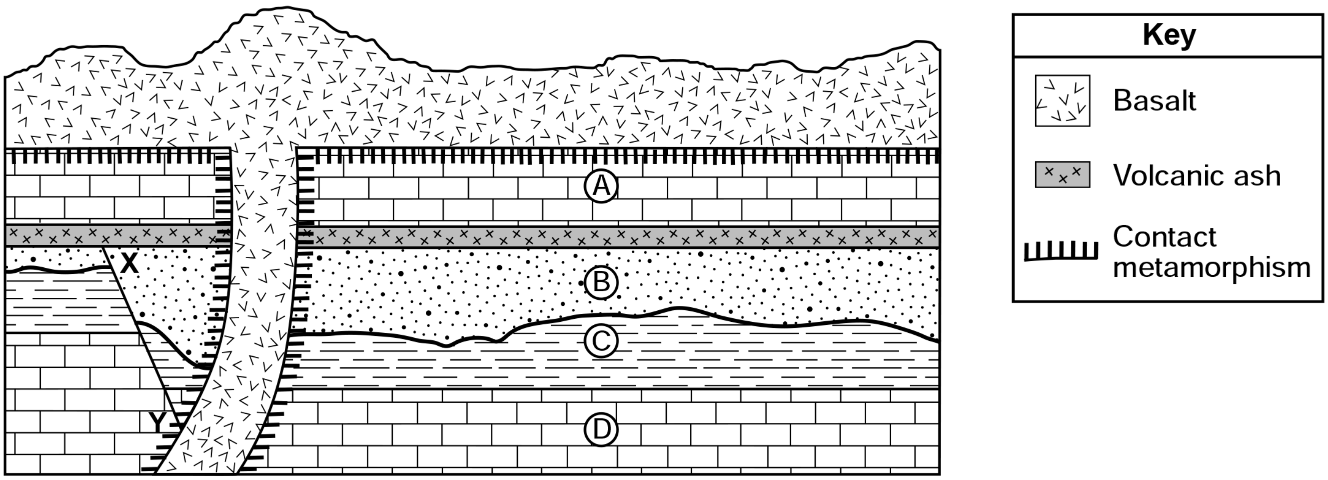
35. The sequence of diagrams below represents the gradual geologic changes in layer **X**, located just below Earth's surface.



Which type of sedimentary rock was formed at layer **X**?

(1) conglomerate (2) shale (3) rock salt (4) coal 35______

Base your answers to 36 through 39 on the diagram below.



36. Layer *A* is limestone. State the name of the metamorphic rock that formed in the zone of contact metamorphism in this layer? ____________________________

37. Layer *B* is sandstone. State the name of the metamorphic rock that formed in the zone of contact metamorphism in this layer? ___________________________

38. Between *C* and *B* is an unconformity. What occurred to produced this?

____

39. What is the age of the basalt compared to the age of the fault line?

(circle one) younger older

40. List two processes that would change accumulated sediments in a delta into sedimentary rocks.

1) ____________________________ 2) ___________________________

41. Give one reason that fossils are rarely found in metamorphic rocks.

____

42. When water evaporates, the minerals get concentrated and can start precipitating out building an evaporate. What rock family are evaporates placed in? ____________________

Rock Cycle Infographic
Set 1 — Answers

1. 3 The three rock families are based on how they were formed. Each family, sedimentary, igneous and metamorphic, has different conditions that produce them.

2. 2 Any rock that undergoes melting and solidifies is classified as an igneous rock.

3. 2 The key word here is “melt.” Metamorphic rocks were made by the conditions of heat and pressure, but they did not melt.

4. 3 The Rock Cycle Infographic chart shows that most sedimentary rocks are deposited in a water environment where they underwent compaction and cementation.

5. 3 The Rock Cycle chart shows: Cooling and Solidification → Igneous rocks.

6. 3 Heat and pressure are the processes that change an existing rock to a metamorphic rock. Cementation is involved in sedimentary rocks.

7. 2 Nonsedimentary rocks are igneous or metamorphic rocks. Heat and pressure, without melting the rock, will change the rock structure, changing it to a metamorphic rock.

8. 3 These conditions are for the igneous rock family. Choice 3, peridotite, is situated on the left side of the Igneous Rock Cycle chart.

9. 1 Volcanoes eject lava, which quickly cools, producing extrusive, fine grain igneous rocks.

10. 1 An intrusive igneous rock cools slowly, forming crystals. This is shown in choice 1.

11. 4 Locate Rock Salt in the Sedimentary Rock section. Notice it is positioned in a water environment —as a shallow sea. The water is a solution of minerals, of which halite is a major part of its composition. If the solution gets too concentrated or the water evaporates, the minerals become concentrated and start to precipitate out. This process can develop a layer of sedimentary rock salt.

12. 3 A biological sedimentary rock is one whose origin is organic–once living. Fossil limestone would have evidence of shells within the limestone rocks.

13. 2 Andesite is located at the top left side of the Igneous Rock Cycle chart. It is positioned just below the volcano. Andesite is an extrusive igneous rock that solidified from lava.

14. 1 Intense heat and pressure produce metamorphic rocks. In the Metamorphic section of the Rock Cycle, phyllite is listed.

15. 2 Gabbro is positioned on the left side of the intrusion in the igneous section. All igneous rocks have undergone solidification—changing from a liquid to a solid.

16. 2 These are the conditions that produce sedimentary rocks. They are also stated in the Rock Cycle chart.

17. 4 Fossils are almost exclusively found in sedimentary rocks. The Sedimentary Rock section shows that mud and clay will undergo compaction and cementation (called lithification) and form shale.