ESP

For the Students of Geology

By:

Dr. Alireza Najafzadeh

Dr. Naser Arzani

Contents

به نام آنکه جان را فکرت آموخت

پیشگفتار

کتاب زبان تخصصی زمین‌شناسی، با توجه به نیاز دانشجویان رشته زمین‌شناسی به آشنایی با زبان تخصصی و بین‌المللی این رشته تدوین شده است که البته اهمیت کاربرد آن در مطالعه و بهره‌جویی از منابع علمی و متون تخصصی، بر همگان مشخص است.

در نگارش کتاب حاضر، سعی شده است که گستره‌ای از موضوعات مختلف زمین‌شناسی انتخاب گردد. به‌علاوه، گزینش متن‌های تخصصی در محدوده موضوعاتی که عموماً در دوره کارشناسی این رشته مورد بحث قرار می‌گیرند، و همچنین خودآموزبودن، از امتیازات شاخص این کتاب است.

در این کتاب، در مجموع هفده درس آورده شده است که در هر یک از دروس، به یک مبحث مهم زمین‌شناسی پرداخته می‌شود. خوانندگان با تعدادی از اصطلاحات و لغات تخصصی زمین‌شناسی، در چارچوب جمله‌بندی‌های ساده تا متوسط آشنا می‌شوند و در ادامه هر درس با تدوین تمرین‌های متنوع و گوناگون، میزان درک مطالب عنوان‌شده، مورد سنجش و ارزیابی قرار می‌گیرد. به خوانندگان عزیز توصیه می‌شود که قبل از مطالعه دروس، راهنمای مطالعه کتاب را با دقت هرچه تمام‌تر خوانده و هدف‌های کلی و رفتاری را قبل از مطالعه هر درس مدنظر قرار دهند.

در اینجا لازم می‌دانیم از همکاران ارجمند، آقایان دکتر منوچهر جعفری‌گهر و مهندس ابراهیم اشراقی که ویراستاری این کتاب را به‌انجام رسانده‌اند و از آقای دکتر شهرام خلیلی‌مبرهن برای راهنمایی‌های ارزنده‌شان صمیمانه تشکر نماییم. همچنین از سرکار خانم مهندس هما بهنام برای نمونه‌خوانی و صفحه‌آرایی مناسب کتاب، از آقای دکتر بهزاد حاج‌علیلو مدیر محترم گروه زمین‌شناسی، از آقای مهندس محمدباقر اکبری برای تدوین کتاب و نیز از سایر عزیزانی که در تهیه این کتاب ما را یاری نموده‌اند کمال تشکر و سپاس خود را ابراز می‌نماییم.

هرچند که تمام سعی و تلاش ما بر آن بود که اثر حاضر، عاری از هرگونه اشتباه باشد،

اما از خوانندگان فهیم و نکته‌سنج درخواست می‌گردد تا با یادآوری خطاهای موجود، ما را در ارائه اثری بهتر در چاپ‌های بعدی کتاب یاری دهند.

علیرضا نجف‌زاده
هیأت‌علمی دانشگاه پیام‌نور کرمان

ناصر ارزانی
هیأت‌علمی دانشگاه پیام‌نور اصفهان

خرداد ۱۳۸۹

راهنمای مطالعه کتاب

هدف کلی

هدف کلی از مطالعه کتاب حاضر، آشنایی دانشجویان رشته زمین‌شناسی با متون علمی و واژه‌های تخصصی انگلیسی زمین‌شناسی و درک مفاهیم مربوط به این رشته به زبان انگلیسی است. بدین منظور، از شاخه‌های مختلف علم زمین‌شناسی، متون متنوعی انتخاب و در قالب ۱۷ درس مختلف ارائه شده است. هر درس از بخش‌های گوناگونی تشکیل گردیده که ذیلاً به‌منظور آشنایی دانشجویان به تشریح نحوه مطالعه هر یک از آنها پرداخته می‌شود.

بخش اول: مترادف و متضاد واژه‌های عام[1]

هدف از تدوین این بخش، آشنایی دانشجویان با مترادف و متضاد بعضی از کلمات و واژه‌های عمومی موجود در متن اصلی هر درس می‌باشد. دانشجویان می‌توانند معانی واژه‌های اصلی، مترادف و متضاد را با استفاده از فرهنگ لغات فرا گیرند. از آنجایی که واژه‌های انگلیسی معمولاً معانی متعددی دارند، واژه‌های مترادف و متضاد به‌کار رفته در این بخش، بر اساس معنی به‌کار رفته واژه مذکور در درس مورد نظر آورده شده‌اند.

بخش دوم: واژه‌ها و عبارت‌های فنی[2]

هدف اصلی از تدوین این بخش، آشنایی دانشجویان با واژه‌ها و اصطلاحات فنی و تخصصی زمین‌شناسی به‌کار رفته در هر درس است. دانشجویان بایستی معانی واژه‌ها مذکور را در فرهنگ لغت‌های مختلف جستجو نموده و در جای مناسب درج نمایند. به منظور جستجوی معانی لغات و واژه‌های عام، می‌توان از فرهنگ لغات عمومی نظیر

1. Synonym and Antonym of common words
2. Technical words

فرهنگ لغات انگلیسی- فارسی حیم، آریان‌پور و ...؛ و جهت جستجوی معانی لغات و واژه‌های تخصصی زمین‌شناسی می‌توان از واژه‌نامه‌ها و فرهنگ‌های زمین‌شناسی که نام آنها در قسمت منابع انتهای کتاب آورده شده است استفاده نمود.

همچنین به منظور آشنایی با تعاریف واژه‌ها و اصطلاحات گوناگون زمین‌شناسی، دانشجویان می‌توانند به فرهنگ لغات و واژه‌نامه‌های[1] زمین‌شناسی مختلفی که نام آنها در قسمت منابع درج گردیده، رجوع نمایند. علاوه بر این، از آنجایی که یادگیری تلفظ صحیح لغات و واژه‌های انگلیسی نیز از اهمیت به‌سزایی برخوردار است، لذا به دانشجویان توصیه می‌شود تلفظ صحیح لغات عمومی را از کتب فرهنگ لغات استخراج نموده و در مقابل هر واژه یادداشت نمایند. آن دسته از لغات تخصصی که تلفظ آنها در این دسته از فرهنگ لغات آورده نشده است، جهت آشنایی دانشجویان در مقابل آنها درج گردیده است. لازم است دانشجویان قبل از مطالعه این بخش از کتاب، به مطالعه دقیق کلید تلفظ[2] لغات مذکور همت گمارند.

بخش سوم: متن اصلی[3]

هدف اصلی از تدوین این بخش از کتاب، ایجاد توانایی لازم در درک متن‌های مختلف زمین‌شناسی، واژه‌ها و اصطلاحات مختلف این رشته است در تهیه این بخش از کتاب و در راستای هدف مذکور، از متون ساده و در عین حال تخصصی زمین‌شناسی استفاده گردیده و سعی گردیده است تا جنبه‌های مختلف این علم را پوشش دهد. متن دروس بر اساس محتوا مرتب شده‌اند و تا حدودی سعی گردیده است تا دروس ابتدایی از سادگی بیشتری برخوردار باشند.

به منظور مطالعه این بخش از کتاب، به دانشجویان توصیه می‌شود ابتدا با توجه به معانی واژه‌های عام و عبارت‌های فنی بخش‌های اول و دوم، متن اصلی را با دقت مطالعه نموده تا به درک صحیحی از مفاهیم جملات و پاراگراف‌های متن دست یابید. برای نیل به این هدف توصیه می‌گردد متن مذکور را چندین بار با دقت مطالعه نمائید.

1. glossary and dictionaries
2. Pronunciation Key
3. Reading

بخش چهارم: تمرینات صحیح و غلط[1]

به منظور تعیین میزان درک مفاهیم اصلی موجود در متن درس، تعدادی عبارت در ارتباط با متن اصلی انتخاب و در این بخش ارائه گردیده است. دانشجویان بایستی به توجه به متن درس، صحیح یا غلطبودن جملات مذکور را مشخص و در محل تعیین‌شده علامت‌گذاری نمایند و جهت تطبیق پاسخ‌های خود، به بخش پاسخ‌نامه[2] انتهای کتاب مراجعه نمایند.

بخش پنجم: تمرینات چهارگزینه‌ای درک متن

هدف از تدوین این بخش، تعیین میزان یادگیری مفاهیم متن اصلی با استفاده از یک سری سؤالات چهارگزینه‌ای است. دانشجویان بایستی پس از مطالعه هر سؤال، ابتدا هر چهار گزینه را مطالعه و از بین آنها، مناسب‌ترین گزینه را انتخاب نموده و پاسخ خود را با پاسخ‌نامه انتهای کتاب مقایسه نمایند. در صورتی که پاسخ غلط را انتخاب نموده باشند، بایستی به متن اصلی درس مراجعه نموده و با مرور مجدد آن، به علت اشتباه خود پی ببرند.

بخش ششم: پاسخ به سؤالات درس

در این بخش، دانشجویان بایستی به سؤالات مطرح‌شده از متن درس، پاسخ دهند. هدف از تدوین این بخش، ایجاد مهارت جمله‌نویسی و ایجاد توانایی در دانشجویان جهت به تحریر درآوردن مفاهیم ذهنی خود به شکل جملات معنی‌دار انگلیسی می‌باشد. در انجام این تمرین بایستی حتی‌المقدور سعی گردد از به‌کار بردن عین جملات و واژه‌های متن درس اجتناب شود.

بخش هفتم: آشنایی با اقسام کلام واژه‌های تخصصی زمین‌شناسی

هدف از ارئه این بخش، آشنایی دانشجویان با اقسام کلام واژه‌های تخصصی زمین‌شناسی (فعل، قید، اسم، صفت و ...) و کاربرد صحیح این اشکال در جملات انگلیسی می‌باشد. بدین منظور، نوع واژه‌های مذکور به همراه معانی انگلیسی آنها در

1. True and False
2. Answer Key

جدولی آورده شده و دانشجویان بایستی پس از مطالعه جدول، اقدام به جای‌گذاری واژه‌های مناسب در جملات گوناگون نموده و در نهایت، پاسخ‌های خود را با پاسخ‌نامه انتهای کتاب مقایسه نمایند.

بخش هشتم: پرکردن جای خالی با واژه‌های مناسب[1]

هدف از تدوین این بخش، تقویت درک مطلب متون تخصصی زمین‌شناسی از طریق خواندن متن و جایگزینی واژه‌های مناسب در مکان‌های خالی توسط دانشجویان می‌باشد. دانشجو بایستی پس از تکمیل متن، آن را مجدداً به‌طور کامل مطالعه و معنی آن را به‌خوبی درک نموده و سپس با توجه به ساختار دستوری زبان فارسی ترجمه نماید. نکته قابل توجهی که باید در خصوص ترجمه متون تخصصی به آن توجه نمود، پرهیز از ترجمه واژه‌به‌واژه جملات انگلیسی است. به‌عبارت دیگر، دانشجویان بایستی از به‌کار بردن ساختار دستور جملات انگلیسی در زبان فارسی جداً خودداری نموده و جملات انگلیسی را به فارسی روان ترجمه نمایند.

به منظور یافتن معادل واژه‌های انگلیسی موجود در متن می‌توان از انواع فرهنگ لغات پیشنهاد شده استفاده نمود.

بخش‌های متفرقه

نظر به اینکه دروس مختلف ارائه‌شده، از ماهیت متفاوتی برخوردار می‌باشند، لذا بسته به موضوع هر درس علاوه بر تمرینات معمول فوق، تمرینات مختلفی با اهداف گوناگون به منظور ایجاد تنوع در یادگیری گنجانیده شده است که از جمله آنها می‌توان به تکمیل جداول و اشکال، جورکردن واژه‌های تخصصی با معانی آنها، جورکردن جملات به‌هم ریخته و غیره اشاره نمود. توضیحات و اهداف مربوط به هر یک از این بخش‌ها در ابتدای هر درس آورده شده است.

1. Fill in the blanks

PRONUNCIATION KEY

(According to: Harding and Johnston (2006))

The symbols used are:

/a/ *as in* back /bak/, active /**ak**-tiv/
/ă/ *as in* abduct /ăb-**dukt**/, gamma /**gam**-ă/
/ah/ *as in* palm /pahm/, father /**fah**-*th*er/
/air/ *as in* care /kair/, aerospace /**air**-ŏspays/
/ar/ *as in* tar /tar/, starfish /**star**-fish/, heart /hart/
/aw/ *as in* jaw /jaw/, gall /gawl/, taut /tawt/
/ay/ *as in* mania /**may**-niă/, grey /gray/
/b/ *as in* bed /bed/
/ch/ *as in* chin /chin/
/d/ *as in* day /day/
/e/ *as in* red /red/
/ĕ/ *as in* bowel /**bow**-ĕl/
/ee/ *as in* see /see/, haem /heem/, caffeine /**ka**f-een/, baby /**bay**-bee/
/eer/ *as in* fear /feer/, serum /**see**r-ŭm/
/er/ *as in* dermal /**de**r-măl/, labour /**lay**-ber/
/ew/ *as in* dew /dew/, nucleus /**new**-klee-ŭs/
/ewr/ *as in* epidural /ep-i-**dew**r-ăl/
/f/ *as in* fat /fat/, phobia /**foh**-biă/, rough /ruf/
/g/ *as in* gag /gag/
/h/ *as in* hip /hip/
/i/ *as in* fit /fit/, reduction /ri-**duk**-shăn/
/j/ *as in* jaw /jaw/, gene /jeen/, ridge /rij/
/k/ *as in* kidney /**ki**d-nee/, chlorine /**klor**een/, crisis /**krÿ**-sis/
/ks/ *as in* toxic /**toks**-ik/
/kw/ *as in* quadrate /**kwod**-rayt/
/l/ *as in* liver /**liv**-er/, seal /seel/
/m/ *as in* milk /milk/
/n/ *as in* nit /nit/
/ng/ *as in* sing /sing/
/nk/ *as in* rank /rank/, bronchus /**bronk**-ŭs/
/o/ *as in* pot /pot/
/ô/ *as in* dog /dôg/
/o/ *as in* buttock /**but**-ŏk/
/oh/ *as in* home /hohm/, post /pohst/
/oi/ *as in* boil /boil/
/oo/ *as in* food /food/, croup /kroop/, fluke /flook/
/oor/ *as in* pruritus /proor-**ÿ**-tis/
/or/ *as in* organ /**or**-găn/, wart /wort/
/ow/ *as in* powder /**pow**-der/, pouch /powch/
/p/ *as in* pill /pil/
/r/ *as in* rib /rib/
/s/ *as in* skin /skin/, cell /sel/
/sh/ *as in* shock /shok/, action /**ak**-shŏn/
/t/ *as in* tone /tohn/
/th/ *as in* thin /thin/, stealth /stelth/
/*th*/ as in then /*th*en/, bathe /bay*th*/
/u/ *as in* pulp /pulp/, blood /blud/
/ŭ/ *as in* typhus /**tÿ**-fŭs/
/û/ *as in* pull /pûl/, hook /hûk/
/v/ *as in* vein /vayn/
/w/ *as in* wind /wind/
/y/ *as in* yeast /yeest/
/ÿ/ *as in* bite /bÿt/, high
/hÿ/, hyperfine /**hÿ**per-fÿn/
/yoo/ *as in* unit /**yoo**-nit/, formula /**form**yoolă/
/yoor/ *as in* pure /pyoor/, ureter /yoor-**ee**ter/
/ÿr/ *as in* fire /fÿr

UNIT 1

THE SCIENCE OF GEOLOGY

هدف کلی

محتوای اصلی این درس که تحت عنوان The science of geology ارائه گردیده است، در خصوص آشنایی با رشته زمین‌شناسی و شاخه‌های مختلف این علم، و نیز آشنایی با لایه‌های مختلف زمین می‌باشد. هدف کلی از تدوین این درس، آشنایی دانشجویان با تعدادی از واژه‌ها و اصطلاحات عمومی و واژه‌های کلیدی زمین‌شناسی و نیز کسب مهارت لازم در درک محتوای متن انگلیسی درس می‌باشد.

هدف‌های رفتاری

انتظار می‌رود دانشجو با مطالعه این فصل بتواند:

۱. معنی واژه‌های عام بخش ۱–۱ را با استفاده از فرهنگ لغات، مشخص نموده و مترادف و متضاد هر یک از واژه‌ها را بیاموزد.
۲. معنی واژه‌های کلیدی و تخصصی بخش ۱–۲ را پس از جستجو در فرهنگ لغات زمین‌شناسی، آموخته و تلفظ صحیح آنها را فرا گیرد.
۳. متن اصلی درس را با دقت مطالعه نموده و درک کلی از مفهوم علم زمین‌شناسی، وظایف زمین‌شناس، شاخه‌های مختلف علم زمین‌شناسی و لایه‌های مختلف زمین داشته باشد.
۴. با توجه به مفهوم کلی درس، صحیح یا غلط‌بودن عبارات تمرین ۱–۴ را مشخص نماید.
۵. با توجه به متن درس، در بخش ۱–۵ مناسب‌ترین گزینه را از بین چهار گزینه، انتخاب و علامت‌گذاری نماید.
۶. پاسخ سؤالات بخش ۱–۶ را با توجه به مفهوم کلی درس، مشخص نموده و سعی نماید تا بدون استفاده از جمله‌بندی‌های متن درس، سؤالات را جواب دهد.
۷. اقسام کلام (اسم، فعل، قید و صفت) واژه تخصصی Geology به همراه تعاریف آنها را آموخته و قادر به به‌کار بردن این واژه‌ها در جملات مختلف تخصصی باشد.
۸. متن انگلیسی بخش ۱–۸ را با واژه‌های داده شده تکمیل و سپس آن را به فارسی روان ترجمه نماید.
۹. با توجه به محتوای اصلی درس، در جدول بخش ۱–۱۰، با استفاده از تعاریف ارائه‌شده در خصوص شاخه‌های مختلف علم زمین‌شناسی، آنها را تعیین و واژه‌های مرتبط با آن رشته را از بین واژه‌های ارائه شده، انتخاب و در سمت راست جدول وارد نماید.
۱۰. جملات پراکنده ارائه شده در بخش ۱–۱۱ را با توجه به مفهوم درس، به صورت سه جمله کامل بازسازی نماید.

1.1. COMMON WORDS: Note the synonyms and antonyms of following words and translate the words into Persian.

Word	Synonym	Antonym
interior	internal, inner, inside	exterior, external, outer
surface	external; superficial	internal, interior
solid	substance exhibiting rigidity	liquid
Subduction	process in which one plate of the Earth's crust being forced underneath another	obduction
deep	in vertical extent	shallow, superficial
below	under	above, over
raise	elevate	lower
internal	interior, inner, inside	external, foreign
beneath	under, below	above
outer	external	inner
hard	rigid	soft
innermost	farthest in, deepest	outermost
similar	alike	different, unlike
extreme	excessive; most, greatest; farthest	slight, moderate

1.2. TECHNICAL WORDS: Note the pronunciation of the following technical words and expressions and translate them into Persian.

1. mineralogy /min-ĕ-**ral**-ŏ-jee ……..
2. petrology /pi-**trol**-ŏ-jee/ ……..
3. sedimentology /sed-ă-men-**tol**-ŏ-jee/ ……..
4. hydrogeology ……..
5. ore deposits ……..
6. stratigraphy /stră-**tig**-ră-fee ……..
7. palaeontology /pay-lee-on-**tol**-ŏ-jee, palee-/ ……..
8. deformation ……..
9. atmosphere ……..
10. environmental geology ……..

11. seismology /sÿz-**mol**-ŏ-jee/ ……..
12. economic geology ……..
13. fossil fuels ……..
14. petroleum /pĕ-**troh**-lee-ŭm/ ……..
15. mineral resources ……..
16. gravel ……..
17. fertilizers ……..
18. reservoir ……..
19. hydrosphere /hÿ-drŏ-sfeer/ ……..
20. biosphere /bÿ-ŏ-sfeer/ ……..
21. earthquakes ……..
22. volcanic ……..
23. eruptions ……..
24. glacier /glay-sher/ ……..
25. soil ……..
26. rock ……..
27. geologic time scale ……..
28. eon /ee-ŏn, ee-on/ ……..
29. era ……..
30. period ……..
31. epoch ……..
32. succession ……..
33. strata ……..
34. igneous rocks /ig-nee-ŭs/ ……..
35. metamorphic rocks /metă-mor-fik/ ……..
36. subduction /sub-duk-shŏn/ ……..
37. mountain building ……..
38. fold ……..
39. fault ……..
40. coal ……..
41. sandstone ……..
42. sedimentary rocks ……..
43. mineral deposit ……..

1.3. Reading

THE SCIENCE OF GEOLOGY

What is geology?

Geology is the study of the Earth, including the material that it is made of the physical and chemical changes that occur on its surface and in its interior, and the history of the planet and its life forms.

What does a geologist do?

Geologists work to understand the history of our planet. The better they can understand Earth's history, the better they can foresee how events and processes of the past might influence the future.

What are the branches of geology?

Geology is divided into several branches, including:

a) mineralogy (the study of minerals and their classification)
b) sedimentology (the scientific study of sediments)
c) petrology (the study of origin, occurrence, structure and history of rocks)
d) economic geology (understanding of ore deposits)
e) stratigraphy (the deposition of successive beds of sedimentary rocks)
f) palaeontology (science of the study of geological periods and the study of fossils)
g) tectonics (the deformation and movement of the Earth's crust)
h) geophysics (using physics to study the Earth's surface, interior, and atmosphere)
i) environmental geology (the application of geology to problems created by man)
j) seismology (study of earthquakes and related phenomena)
k) hydrogeology (study of groundwater)
l) geochemistry (study of the chemical composition of the Earth)

The Earth and its materials

The Earth's radius is about 6370 kilometers (Fig. 1-1). If you could

drive a magical vehicle from the center of the Earth to the surface at 100 kilometers per hour, the journey would take more than two and a half days.

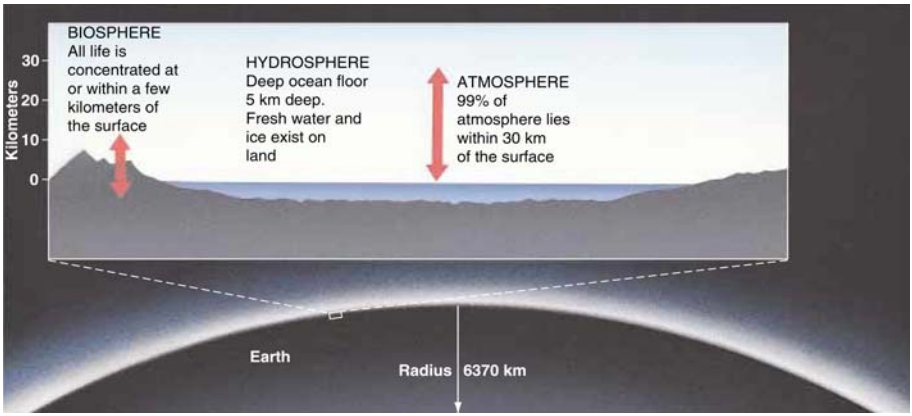


Figure 1-1. Most of the Earth is solid rock, surrounded by the hydrosphere, the biosphere, and the atmosphere.

Most of the Earth is composed of **rocks**. Rocks, in turn, are composed of **minerals**. Although more than 3500 different minerals exist, fewer than a dozen are common. Geologists study the origins, properties, and compositions of both rocks and minerals. Geologists also explore the Earth for the resources needed in our technological world: fossil fuels such as coal, petroleum, and natural gas; mineral resources such as metals; sand and gravel; and fertilizers. Some search for water in reservoirs beneath Earth's surface.

Internal processes

Processes that originate deep in the Earth's interior are called **internal processes**. These are the driving forces that raise mountains, cause earthquakes, and produce volcanic eruptions.

Surface or external processes

Surface or **external processes** are all of those processes that form the Earth's surface. Most surface processes are driven by water, although wind, ice, and gravity are also significant.

Layers surrounding the Earth

The Earth is surrounded by three layers:

1. The **hydrosphere** includes water in streams, wetlands, lakes, and oceans; in the atmosphere; and frozen in glaciers (Fig. 1-1). It also includes ground water present in soil and rock to a depth of at least 2 kilometers.
2. The **atmosphere** is a mixture of gases, mostly nitrogen and oxygen (Fig. 1-1). It is held to the Earth by gravity and thins rapidly with altitude. Ninety-nine percent is concentrated within 30 kilometers of the Earth's surface, but a few traces remain even 10,000 kilometers above the surface.
3. The **biosphere** is the thin zone near the Earth's surface that is occupied by life (Fig. 1-1). It includes the uppermost solid Earth, the hydrosphere, and the lower parts of the atmosphere. Land plants grow on the Earth's surface, with roots penetrating at most a few meters into soil. Animals live on the surface, fly a kilometer or two above it, or burrow a few meters underground. Sea life also concentrates near the ocean surface, where sunlight is available.

Layers of the Earth

Scientists generally agree that the Earth formed by accretion of small particles. They also agree that the modern Earth is layered (Fig. 1-2).

1. The **crust** is the outermost and thinnest layer. Because the crust is relatively cool, it consists of hard, strong rock. Crust beneath the oceans differs from that of continents. Oceanic crust is 5 to 10 kilometers thick and is composed mostly of a dark, dense rock called **basalt**. In contrast, the average thickness of continental crust is about 20 to 40 kilometers, although under mountain ranges it can be as much as 70 kilometers thick. Continents are composed primarily of a light colored, less dense rock called **granite**.
2. The **mantle** lies directly below the crust. It is almost 2900 kilometers thick and makes up 80 percent of the Earth's volume. Although the chemical composition may be similar throughout the

mantle, Earth temperature and pressure increase with depth. The upper part of the mantle consists of two layers which are named **lithosphere** and **asthenosphere**.

The uppermost mantle is relatively cool and consequently is hard, strong rock. In fact, its mechanical behavior is similar to that of the crust. The outer part of the Earth, including both the uppermost mantle and the crust, make up the lithosphere.

At a depth, varying from about 75 to 125 kilometers, the strong, hard rock of the lithosphere gives way to the weak, plastic asthenosphere. In general, 1 to 2 percent of the asthenosphere is liquid, and because it is plastic, the asthenosphere flows slowly, perhaps at a rate of a few centimeters per year.

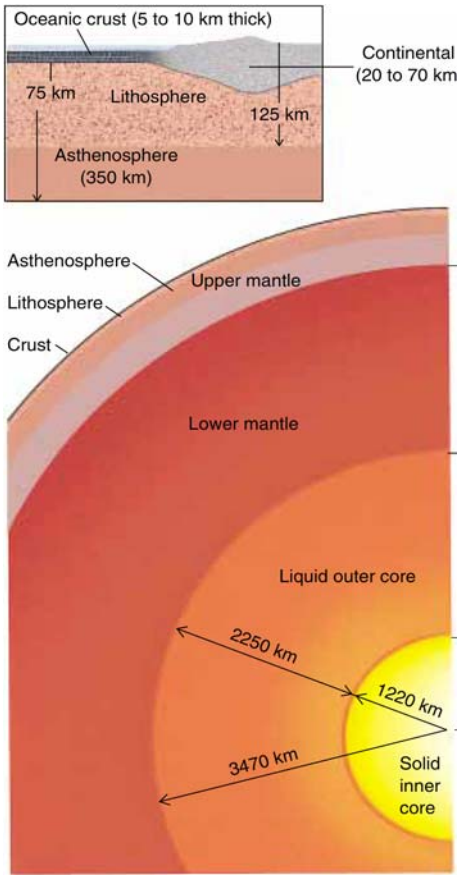


Figure 1-2. The Earth is a layered planet.

3. The **core** is the innermost of the Earth's layers. It is a sphere with a radius of about 3470 kilometers and is composed largely of iron and nickel. The outer core is molten because of the high temperature in that region. Near its center, the core's temperature is about $6000^{\circ C}$, as hot as the Sun's surface. The pressure is greater than 1 million times that of the Earth's atmosphere at sea level. The extreme pressure overwhelms the temperature effect and compresses the inner core to a solid.

EXERCISES

1.4. According to the passage, which of the following statements are "true" or "false"? Insert "T" or "F" in the boxes at the right.

1. Sand and gravel are mineral resources.
2. The atmosphere is a mixture of gases, mostly hydrogen and oxygen.
3. The biosphere includes the lithosphere, the hydrosphere, and the lower parts of the atmosphere.
4. Oceanic crust is 5 to 10 kilometers thick and is composed mostly of basalt.
5. The outer core is solid because of the high pressure in that region.
6. The asthenosphere is mechanically weak and plastic.

1.5. Choose a, b, c, or d which best completes each item.

1. Coal, petroleum, and natural gas are ……..
   a) rocks b) minerals

c) fossil fuels d) mineral resources

2. What is the composition of continents?
   a) Basalt b) Granite
   c) Lithosphere d) Rocks
3. What does the upper part of the mantle consist of?
   a) lithosphere and asthenosphere b) lithosphere and biosphere
   c) asthenosphere and hydrosphere d) biosphere and hydrosphere
4. What is the composition of the core?
   a) Nickel and Iron b) Liquid
   c) Basalt d) Granite

1.6. Write the answers to the following questions in your own words.

1. What type of igneous rock is the most abundant constituent of continental crust? What type makes up most oceanic crust?

……
……
……
……
……
……
……

2. Draw a cross-sectional view of the Earth. List all the major layers and the thickness of each.

……
……
……
……
……
……
……

3. Describe the important differences between the lithosphere and the

asthenosphere.

……
……
……
……
……
……
……

4. Describe some important differences between oceanic crust and continental crust.

……
……
……
……
……
……
……

1.7. Note the following technical words and their definitions and translate the words into Persian.

Technical words	Definitions
Geology (noun)	study of the history and development of the Earth
Geologists (noun)	one who studies the history and development of the Earth
Geologic (adjective)	of or pertaining to geology
Geological (adjective)	of or pertaining to geology
Geologically (adverb)	from a geological standpoint

Now, fill in the blanks with the appropriate words.

1. ..... work to understand the history of our planet.
2. Geologists have divided Earth history into units displayed in the

..... time scale.

3. An important part of ..... is the study of how Earth's materials, structures, processes and organisms have changed over time.
4. Mars is still active .....
5. Nicolas Steno (1638-1686) articulated three basic ..... principles.
6. Only a small portion of the surface of the earth has been ..... explored.

1.8. Fill in the blanks with the following words and translate the passage into Persian.

"erosion", "earthquakes", "volcanic", "soils", "processes", "crustal"

What is physical geology?

Physical geology is the study of the earth's rocks, minerals, and ……**1**……. and how they have formed through time. Complex internal processes such as plate tectonics and mountain-building have formed these rocks and brought them to the earth's surface. ……**2**……. are the result of the sudden movement of ……**3**……. plates, releasing internal energy that becomes destructive at the surface. Internal heat and energy are released also through ……**4**……. eruptions. External ……**5**……. such as glaciation, running water, weathering, and ……**6**……. have formed the landscapes we see today.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

1.9. Rearrange the sentence parts of the following table into three different sentences.

consists of lithosphere	is a solid material	the upper part of the mantle
that is composed of various minerals	outer core	a rock
rich in nickel and iron	and asthenosphere	is believed to be a layer of molten liquid

1. ……...…
2. ……
3. ……...…

1.10. Read the following passage and translate into Persian.

Geologic Time

Geoscientists have estimated the earth to be about 4.5 billion years old. As the crust cooled, early geologic processes were largely volcanic, building up continental crust and a primitive atmosphere.

Bacterial forms of life have been found in rocks that are billions of years old. Complex oceanic organisms such as trilobites began to appear only about 600 million years ago. From about 66 million to 245 million years ago, dinosaurs and other reptiles developed all over the world. In contrast, human beings have existed in only about the last 3 million years, less than a thousandth of the age of Earth.

.....

.....

.....

.....

.....

.....

.....

.....

.....

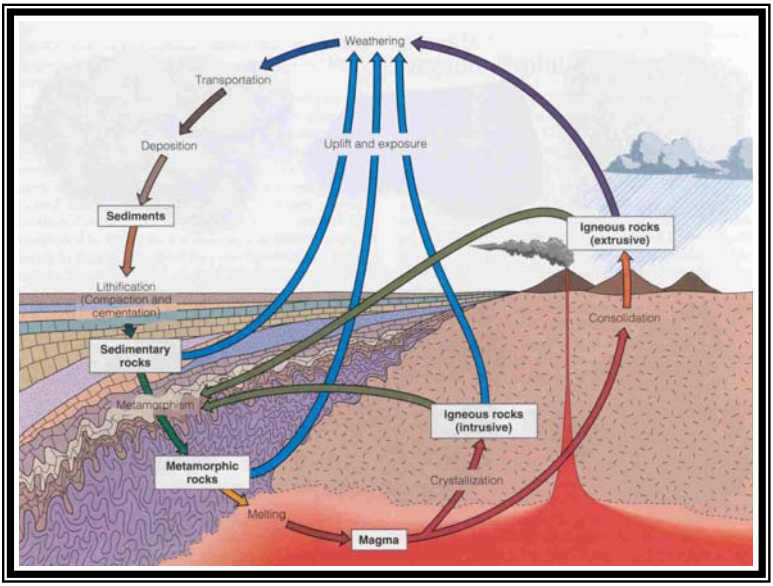
.....

1.11. Write the name of relevant geological branches in front of the corresponding definition and put the examples into the table too. "igneous rocks", "mineral resources", "folds", "coal", "rock analysis", "nonmetallic minerals", "faults", "metamorphic rocks", "subduction", "sandstone", "mountain building", "sandstone", "sedimentary rocks"

Geological branches	Definition	Example
	Dealing with the origin, occurrence, structure, and history of rocks.	
	The application of geologic knowledge to the search for the understanding of mineral deposits.	
	The study of the distribution of the chemical elements in minerals, ores, rocks, soils, water and the atmosphere.	
	Deals with the form, arrangement and internal structure of the rocks.	
	Deals with the original succession and age relations of rock strata.	
	Dealing with the broad architecture of the outer part of the earth.	

UNIT 2

THE ROCK CYCLE



هدف کلی

محتوای اصلی این درس که تحت عنوان The rock cycle ارائه گردیده است، در خصوص آشنایی مقدماتی با انواع سنگ‌های آذرین، رسوبی و دگرگونی و چرخه بین آنها می‌باشد. هدف کلی از تدوین این درس، آشنایی دانشجویان با تعدادی از واژه‌ها و اصطلاحات عمومی و واژه‌های کلیدی زمین‌شناسی و نیز کسب مهارت لازم در درک محتوای متن انگلیسی درس می‌باشد.

هدف‌های رفتاری

انتظار می‌رود دانشجو با مطالعه این فصل بتواند:

۱. معنی واژه‌های عام بخش ۲-۱ را با استفاده از فرهنگ لغات، مشخص نموده و مترادف و متضاد هر یک از واژه‌ها را بیاموزد.
۲. معنی واژه‌های کلیدی و تخصصی بخش ۲-۲ را پس از جستجو در فرهنگ لغات زمین‌شناسی، آموخته و تلفظ صحیح آنها را فرا گیرد.
۳. متن اصلی درس را با دقت مطالعه نموده و درک کلی از انواع سنگ‌ها و چرخه بین آنها داشته باشد.
۴. با توجه به مفهوم کلی درس، صحیح یا غلط‌بودن عبارات تمرین ۲-۴ را مشخص نماید.
۵. با توجه به متن درس، در بخش ۲-۵ مناسب‌ترین گزینه را از بین چهار گزینه، انتخاب و علامت‌گذاری نماید.
۶. پاسخ سؤالات بخش ۲-۶ را با توجه به مفهوم کلی درس، مشخص نموده و سعی نماید تا بدون استفاده از جمله‌بندی‌های متن درس، سؤالات را پاسخ دهد.
۷. اقسام کلام (اسم، فعل، قید و صفت) واژه تخصصی Sediment به همراه تعاریف آنها را آموخته و قادر به به‌کار بردن این واژه‌ها در جملات مختلف تخصصی باشد.
۸. متن انگلیسی بخش ۲-۸ را با واژه‌های داده‌شده تکمیل و سپس آن را به فارسی روان ترجمه نماید.
۹. با توجه به محتوای اصلی درس، در جدول بخش ۲-۹، با استفاده از تعاریف ارائه‌شده در خصوص انواع گروه‌های سنگی، نوع آنها را تعیین و مثال‌هایی از سنگ‌های مربوط به هر گروه را از بین واژه‌های ارائه شده، انتخاب و در سمت راست جدول وارد نماید.
۱۰. مکان‌های خالی نمودار چرخه سنگ‌ها (بخش ۲-۱۰) را با استفاده از واژه‌های داده‌شده تکمیل نماید.
۱۱. جملات پراکنده ارائه‌شده در بخش ۲-۱۱ را با توجه به مفهوم درس، به صورت جملات کامل بازسازی نماید.

2.1. COMMON WORDS: Note the synonyms and antonyms of following words and translate the words into Persian.

Word	synonym	antonym
different	not the same	similar
tiny	Very small	huge
solidify	made hard or solid	liquefy
within	inside part, inner place,	outside
attraction	inward pull	act of driving away
compact	pack tightly together, condense	loose
harden	make hard or tough; become hard	soften
include	contain	exclude
enter	go into	leave
bury	put in the ground and cover with dirt	exhume
permanent	lasting	temporary

2.2. TECHNICAL WORDS: Note the pronunciation of the following technical words and expressions and translate them into Persian.

1. magma /mag-mă/ ……..
2. extrusive rocks ……..
3. obsidian /ob-sid-ee-ăn/ ……..
4. granite /granit/ ……..
5. basalt /bă-sawlt, bass-awlt/ ……..
6. andesite /an-dĕ-zÿt/ ……..
7. porphyry /por-fă-ree/ ……..
8. rhyolite /rÿ-ŏ-lÿt/ ……..
9. plutonic /ploo-tonn-ik/ ……..
10. intrusive ……..
11. diorite /dÿ-ŏ-rÿt/ ……..
12. unconsolidate ……..
13. shale ……..
14. sandstone ……..

15. limestone ……..
16. gneiss /nÿss/ ……..
17. biotite schist /bÿ-ŏ-tÿt/ /shist/ ……..
18. foliated ……..
19. marble ……..
20. rock cycle ……..
21. lithification /lith-ă-fă-kay-shŏn/ ……..
22. solidification ……..

2.3. Reading

THE ROCK CYCLE

Rocks tell the story of the Earth

The Earth is made of rock, from the tallest mountains to the floor of the deepest ocean. Thousands of different types of rocks and minerals have been found on Earth. Most rocks at the Earth's surface are formed from only eight elements (oxygen, silicon, aluminum, iron, magnesium, calcium, potassium, and sodium), but these elements are combined in a number of ways to make rocks that are very different.

Rocks are continually changing. Wind and water wear them down and carry bits of rock away; the tiny particles accumulate in a lake or ocean and harden into rock again. The oldest rock that has ever been found is more than 3.9 billion years old. The Earth itself is at least 4.5 billion years old and rock forming and rock-destroying processes have been active for billions of years.

Types of Rocks

Geologists classify rocks in three groups, according to the major Earth processes that formed them. The three rock groups are **igneous**, **sedimentary**, and **metamorphic rocks**.

Igneous Rocks

Igneous rocks are formed from **melted rock** that has cooled and solidified. When rocks are buried deep within the Earth, they melt because of the high pressure and temperature; the molten rock (called **magma**) can then flow upward or even be erupted from a **volcano** onto the Earth's surface (**extrusive rocks**).

When magma cools slowly, usually at depths of thousands of feet, crystals grow from the molten liquid, and a **coarse-grained** rock forms. When magma cools rapidly, usually at or near the Earth's surface, the crystals are extremely small, and a **fine-grained** rock results. A wide variety of rocks are formed by different cooling rates and different chemical compositions of the original magma. **Obsidian** (**volcanic glass**), **granite**, **basalt**, and **andesite porphyry** are four of the many types of igneous rocks with different **textures**. The texture of a rock refers to the size, shape, and arrangement of its mineral grains, or crystals (Table 2-1).

Common igneous (volcanic rocks) are basalt, andesite, and rhyolite. When magmas crystallize deep underground they look different from volcanic rocks because they cool more slowly and, therefore, have larger crystals.

Igneous rocks cooled beneath the Earth's surface are called **intrusive** (**plutonic**) rocks. The intrusive equivalents of basalt, andesite, and rhyolite are gabbro, diorite, and granite, respectively.

Table 2-1. Igneous rocks textures based on grain size.

GRAIN SIZE	NAME OF TEXTURE
No mineral grains (obsidian)	Glassy
Too fine to see with naked eye	Very fine grained
Up to 1 millimeter	Fine grained
1-5 millimeter	Medium grained
More than 5 millimeter	Coarse grained
Relatively large grains in a finer-grained matrix	Porphyritic

Sedimentary Rocks

Sedimentary rocks are formed at the surface of the Earth, either in

water or on land. They are layered accumulations of sediments: fragments of rocks, minerals, or animal or plant material. Temperatures and pressures are low at the Earth's surface, and sedimentary rocks show this fact by their appearance and the minerals they contain.

Most sedimentary rocks become **cemented** together by minerals and chemicals or are held together by electrical attraction; some, however, remain loose and unconsolidated. The layers are normally parallel or nearly parallel to the Earth's surface. Compacted and dried mud flats harden into **shale**.

Common sedimentary rocks include **sandstone**, **limestone**, and shale. These rocks often start as sediments carried in rivers and deposited in lakes and oceans. When buried, the sediments lose water and become cemented to form rock.

Metamorphic Rocks

Sometimes sedimentary and igneous rocks are subjected to pressures so intense or heat so high that they are completely changed. They become metamorphic rocks, which form while deeply buried within the Earth's crust.

The process of **metamorphism** does not melt the rocks, but instead transforms them into denser, more compact rocks. New minerals are created either by rearrangement of mineral components or by reactions with fluids that enter the rocks. Some kinds of metamorphic rocks, "**granite gneiss**" and "**biotite schist**" are two examples, are strongly banded or **foliated**. ("Foliated" means the parallel arrangement of certain mineral grains that gives the rock a striped appearance.) Pressure or temperature can even change previously metamorphosed rocks into new types.

Common metamorphic rocks include schist, **marble**, and **gneiss**. Sedimentary rock shale (formed mostly of clay sediments) when buried and heated to high temperatures (300-500˚C) becomes transformed or metamorphosed into **schist**.

No rock is permanent over geologic time; instead, all rocks

change slowly from one of the three rock types to another. This continuous process is called the **rock cycle** (Fig. 2-1). The transformations from one rock type to another can follow many different paths. For example, weathering may reduce a metamorphic rock to sediment, which then becomes cemented to form a sedimentary rock. An igneous rock may be metamorphosed. The rock cycle simply expresses the idea that rock is not permanent but changes over geologic time.

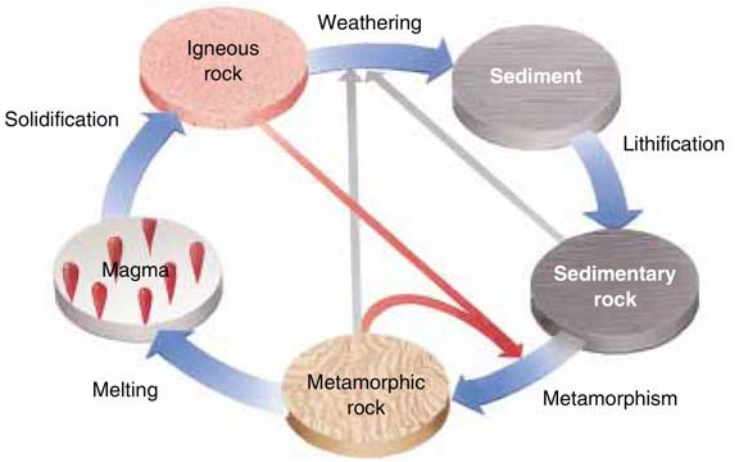


Figure 2-1. The rock cycle shows that rocks change continuously over geologic time. The arrows show paths that rocks can follow as they change.

EXERCISES

2.4. According to the passage, which of the following statements are "true" or "false"? Insert "T" or "F" in the boxes at the right.

1. The oldest rock that has ever been found is less than 3.9 billion years old.

2. The process of metamorphism melts the rocks.

3. Volcanic rocks cool rapidly, so are fine-grained.

4. Compacted and dried mud flats harden into schist.

5. The intrusive equivalent of basalt is diorite.

6. The extrusive equivalent of granite is rhyolite.

2.5. Choose a, b, c, or d which best completes each item.

1. A (An) …….. igneous rock forms when magma erupts and solidifies on the Earth's surface.
   a) intrusive b) extrusive
   c) magmatic d) coarse grain
2. Diorite is the …….. equivalent of andesite.
   a) magmatic b) fine grain
   c) plutonic d) igneous rock
3. Weathering may reduce a metamorphic rock to ……..
   a) sediment b) igneous rock
   c) schist d) rock cycle
4. When magma cools slowly, crystals grow from the …….. liquid.
   a) magma b) intrusive
   c) cooling d) molten
5. Igneous rocks form when a hot, molten liquid called magma ……..
   a) solidifies b) intrusive
   c) lithification d) weathered
6. Pressure or temperature can even change previously metamorphosed rocks into new ……..
   a) sedimentary rocks b) metamorphic rocks
   c) igneous rock d) minerals
7. Igneous rocks could change in to sediments by ……..
   a) lithification b) melting

c) solidification d) weathering

2.6. Write the answers to the following questions in your own words.

1. What is the difference between intrusive and extrusive rocks regarding the cooling process and the size of the crystals?

……
……
……
……
……
……
……

2. Describe the three main classes of rocks.

……
……
……
……
……
……
……

3. What criteria are used to categorize rocks into the three classes that you described in question 2?

……
……
……
……
……
……
……

4. List two common rock types in each of the three main classes of rocks. Were these rock names familiar to you before you read this unit?

……
……
……
……
……
……
……

2.7. Note the following technical words and their definitions and translate the words into Persian.

Technical words	Definitions
Sediment (noun)	material deposited by ice or wind or water
Sedimentary (adjective)	formed by deposits of sediment
Sedimentation (noun)	accumulation of sediment
Sedimentology	The scientific study of sediments and the determination of their origin
Sedimentologist	one who studies the sediments

Now, fill in the blanks with the appropriate words.

1. Common ..... rocks include sandstone, limestone, and shale.
2. There are no marine ..... in the rift valley of Africa.
3. ..... in marine systems is a dynamic process.
4. Detailed ..... analyses indicate that some beds were deposited from storm-generated flows.
5. Role of channel geometry is very important in controlling the morphology and ..... of flood deposits.
6. ..... image past processes and compare them to modern ones.

2.8. Fill in the blanks with the following words and translate the passage into Persian.
"fine-grained", "surface", "loose", "mountain, "textures", "silicate", "porphyry", "solid", "volcanic", "molten"

Rocks

Geologists separate rocks into three classes based on how they form: igneous rocks, sedimentary rocks, and metamorphic rocks. Igneous rocks form when a hot, ……**1**……. liquid called magma solidifies. Sedimentary rocks form when ……**2**……. sediment, such as sand and clay, becomes cemented to form a ……**3**……. rock. Metamorphic rocks form when older igneous, sedimentary, or other metamorphic rocks change because of high temperature and/or pressure or are deformed during ……**4**……. building.

The temperature of magma varies from about 600˚C to 1400˚C. Nearly all magmas are ……**5**……. magmas. Magma usually rises toward the Earth's surface because it is of lower density than rocks that surround it.

An extrusive, or ……**6**……., igneous rock forms when magma erupts and solidifies on the Earth's ……**7**……. An intrusive, or plutonic, rock forms when magma cools and solidifies below the surface. Plutonic rocks typically have medium- to coarse-grained ……**8**……., whereas volcanic rocks commonly have very fine- to fine-grained textures. A ……**9**……. consists of larger crystals imbeded in a ……**10**……. matrix.

.....
.....
.....
.....
.....
.....
.....
.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

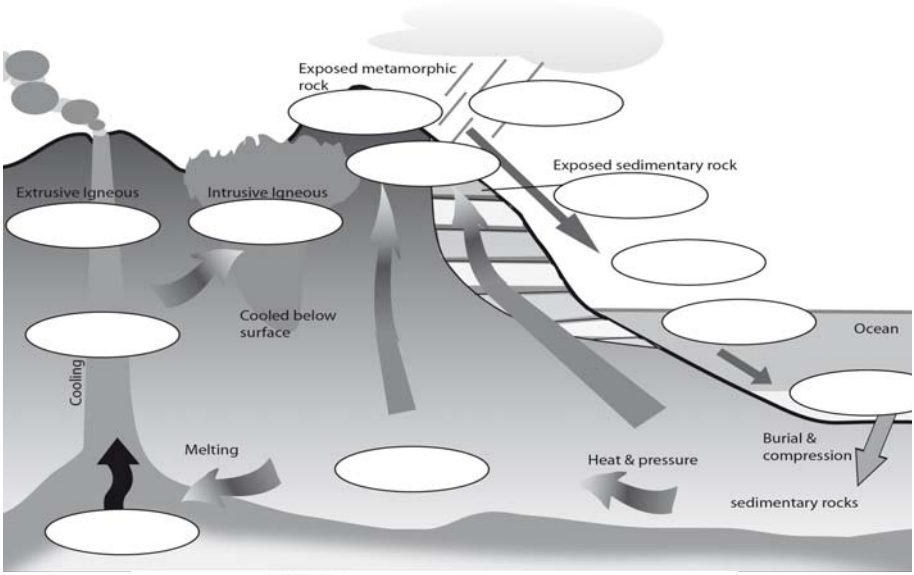
.....

2.9. Match the sentence parts to form a complete sentence.

1. The marine fossils of Mount Everest tell us that	A) metamorphosed into schist.
2. Under certain conditions, rocks of the upper mantle and lower crust melt,	B) its temperature and pressure increase.
3. When the beach sand is cemented,	C) a coarse-grained rock forms.
4. When a rock is buried,	D) the limestone formed in the sea.
5. When magma cools slowly	E) forming a hot liquid called magma.
6. Shale when buried and heated to high temperatures (300- 500˚C)	F) it becomes sandstone.

1—— 2—— 3—— 4—— 5—— 6——

2.10. Label the missing parts of the rock cycle.



Deposition
Limestone
Weathering
Granite
Marble
Basalt
Magma
Exposure
Igneous rocks
Sediments
Metamorphic rocks
Erosion and transport

2.11. Write the name of relevant types of rocks in front of the corresponding definition and put the examples into the table too.
"marble", "granite", "limestone", "coal", "slate", "basalt", "sandstone", "shale", "lava".

Types	Definition	Example
	These rocks were formed from the remains of animals or plants and other rocks which had been crushed together.	
	These rocks were formed when hot, molten volcanic material cooled and solidified.	
	These rocks were once igneous or sedimentary and were changed by great heat and pressure.	

UNIT 3

HISTORICAL GEOLOGY

هدف کلی

محتوای اصلی این درس که تحت عنوان Historical geology ارائه گردیده است، در خصوص آشنایی با روش‌های تعیین سن، انواع دگرشیبی‌ها و دوران‌های زمین‌شناسی می‌باشد. هدف کلی از تدوین این درس، آشنایی دانشجویان با تعدادی از واژه‌ها و اصطلاحات عمومی و واژه‌های کلیدی زمین‌شناسی و نیز کسب مهارت لازم در درک محتوای متن انگلیسی درس می‌باشد.

هدف‌های رفتاری

انتظار می‌رود دانشجو با مطالعه این فصل بتواند:

۱. معنی واژه‌های عام بخش ۳-۱ را با استفاده از فرهنگ لغات، مشخص نموده و مترادف و متضاد هر یک از واژه‌ها را بیاموزد.
۲. معنی واژه‌های کلیدی و تخصصی بخش ۳-۲ را پس از جستجو در فرهنگ لغات زمین‌شناسی، آموخته و تلفظ صحیح آنها را فرا گیرد.
۳. متن اصلی درس را با دقت مطالعه نموده و درک کلی از روش‌های تعیین سن، انواع دگرشیبی‌ها و دوران‌های مختلف زمین‌شناسی داشته باشد.
۴. با توجه به مفهوم کلی درس، صحیح یا غلط‌بودن عبارات تمرین ۳-۴ را مشخص نماید.
۵. با توجه به متن درس، در بخش ۳-۵ مناسب‌ترین گزینه را از بین چهار گزینه، انتخاب و علامت‌گذاری نماید.
۶. پاسخ سؤالات بخش ۳-۶ را با توجه به مفهوم کلی درس، مشخص نموده و سعی نماید تا بدون استفاده از جمله‌بندی‌های متن درس، سؤالات را جواب دهد.
۷. اقسام کلام (اسم، فعل، قید و صفت) واژه تخصصی Correlate به همراه تعاریف آنها را آموخته و قادر به به‌کار بردن این واژه‌ها در جملات مختلف تخصصی باشد.
۸. جملات پراکنده ارائه‌شده در بخش ۳-۸ را با توجه به مفهوم درس، به صورت چهار جمله کامل بازسازی نماید.
۹. متن انگلیسی بخش ۳-۹ را به فارسی روان ترجمه نماید.

3.1. COMMOM WORDS: Note the synonyms and antonyms of following words and translate the words into Persian.

Word	Synonym	Antonym
present	of the current times	past, future
helpful	useful	useless
progressive	changing gradually	changing abruptly
Prior to	before	subsequent
extinct	nonexistent, dead	extant
important	significant	insignificant
restrict	limit	unlimit
separated	segregated, set apart	linked
diversity	variety	uniformity

3.2. TECHNICAL WORDS: Note the pronunciation of the following technical words and expressions and translate them into Persian.

1. geologic time scale ……..
2. geological features ……..
3. field ……..
4. uniformitarianism /yoo-nă-for-mă-tairee-ă-niz-ăm/ ……..
5. geologic processes ……..
6. relative age ……..
7. absolute age ……..
8. principle of superposition ……..
9. principle of original horizontality ……..
10. cross-bedded sediment ……..
11. layered sequences ……..
12. principle of faunal succession ……..
13. fossil species ……..
14. inclusion ……..
15. unconformity /un-kŏn-for-mă-tee/ ……..
16. erosional surfaces ……..

17. conformable ……..
18. interruption ……..
19. disconformity /diss-kŏn-for-mă-tee/ ……..
20. angular unconformity ……..
21. tectonic activity ……..
22. nonconformity ……..
23. correlation ……..
24. index fossils ……..
25. key beds ……..
26. time correlation ……..
27. geologic column ……..
28. geologic time scale ……..
29. eon /ee-ŏn, ee-on/ ……..
30. era ……..
31. period ……..
32. epoch ……..
33. Hadean /hay-dee-ăn/ ……..
34. Archean /ar-kee-ăn/ ……..
35. Proterozoic Eon /prot-ĕ-rŏ-zoh-ik/ ……..
36. phytoplankton /fÿ-toh-plank-tŏn/ ……..
37. cephalopodea /sef-ă-lop-ŏ-dă/ ……..
38. ammonoidea /am-ŏ-noi-dee-ă/ ……..

3.3. Reading

HISTORICAL GEOLOGY

The history of the Earth

The earth is estimated to be about 4.5 billion years old. Our knowledge of its history comes from a number of sources. The geologic time scale is built through scientific methods and calculations as well as from the interrelationships of geological features as observed in the field.

The principle of **uniformitarianism** ("the present is the key to the past") is helpful in that we can measure the rates of geologic processes we see today and apply them to the geologic past.

Geologic time

Geologists measure geologic time in two different ways, **relative age** and **absolute age.**

a) Relative age: Geologists use some basic, simple principles to solve "which came first":

The **principle of superposition** states that sedimentary rocks become younger from bottom to top. In Figure 3-1, the sedimentary layers become progressively younger in the order E, D, C, B, and A.

The **principle of original horizontality** states that most sedimentary rocks (an exception is cross-bedded sediment) formed as nearly horizontal layers. Any layered sequences that are now tilted were moved by later geologic processes.

According to the **principle of crosscutting relationships**, any rock that cross-cuts another rock is younger than the rock it cross-cuts.

The **principle of faunal succession** states that fossil species succeed one another in undisturbed rocks in a definite and recognizable order around the world.

b) Absolute age is age in years. Dinosaurs became extinct 65 million years ago. Absolute age tells us both the order in which events occurred and the amount of time that has passed since they occurred.

Unconformities

Layers of sedimentary rocks are **conformable** if they were deposited without interruption. An **unconformity** represents an interruption in deposition, usually of long duration.

Several types of unconformities exist. In a **disconformity**, the sedimentary layers above and below the unconformity are parallel (Fig. 3-1).

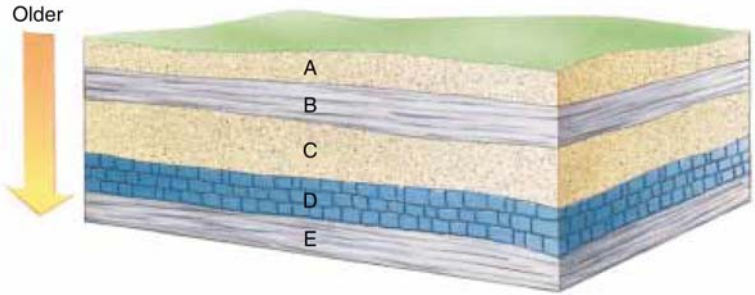


Figure 3-1. In a sequence of sedimentary beds, the oldest bed is the lowest, and the youngest is on top. These beds become older in the order A, B, C, D, and E.

In an **angular unconformity**, tectonic activity tilted older sedimentary rock layers before younger sediment accumulated (Fig. 3-2).

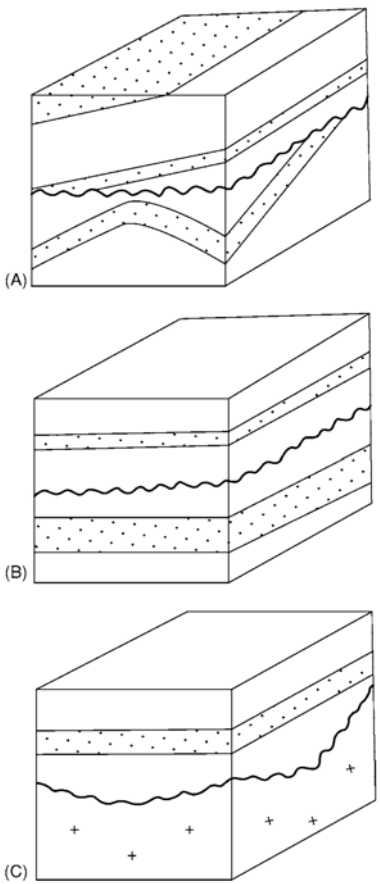


Figure 3-2. Types of unconformity. (A) Angular unconformity. (B) Disconformity. (C) Nonconformity.

A **nonconformity** is an unconformity in which sedimentary rocks lie on igneous or metamorphic rocks (Fig. 3-3).

Figure 3-3. Angular unconformity between folded sandstones and Triassic fluvial deposits, southern Portugal.

Fossils and faunal succession

Geologic time periods can be well defined by the **fossil** remains of animal and plant species within them. **Palaeontology** is the study of fossils. Rocks that contain the same kinds of fossils formed over the same range of geologic time in which the species existed on the earth.

Correlation, index fossils and key beds

Correlation is the showing of equivalency of rocks that are geographically separated. **Index fossils** and **key beds** are important tools in **time correlation**. It shows that sedimentary rocks from different geographic localities formed at the same time. Worldwide correlation of rocks of all ages has resulted in the **geologic column**, a composite record of rocks formed throughout the history of the Earth.

Index fossils are those species that lived only during a restricted period. A key bed is a thin, widespread sedimentary layer that was deposited rapidly and synchronously over a wide area and is easily recognized.

The geologic column and time scale

Geologists have divided Earth history into units displayed in the **geologic time scale** (Table 3–1). The units are called eons, eras, periods, and epochs and are identified primarily by the types of life that existed at the various times.

The two earliest eons, the Hadean and Archean, cover the first 2.5 billion years of Earth history. Life originated during Archean time. Living organisms then evolved during the Proterozoic Eon. However, most Proterozoic organisms had no hard parts such as shells and bones. Most were single celled, although some multi cellular organisms existed (Table 3–1).

Proterozoic Eon

The Proterozoic Eon ended about 538 million years ago. Then, within a short time, perhaps as little as 5 million years, many new species evolved. These organisms were biologically more complex than their Proterozoic ancestors, and many had shells and skeletons.

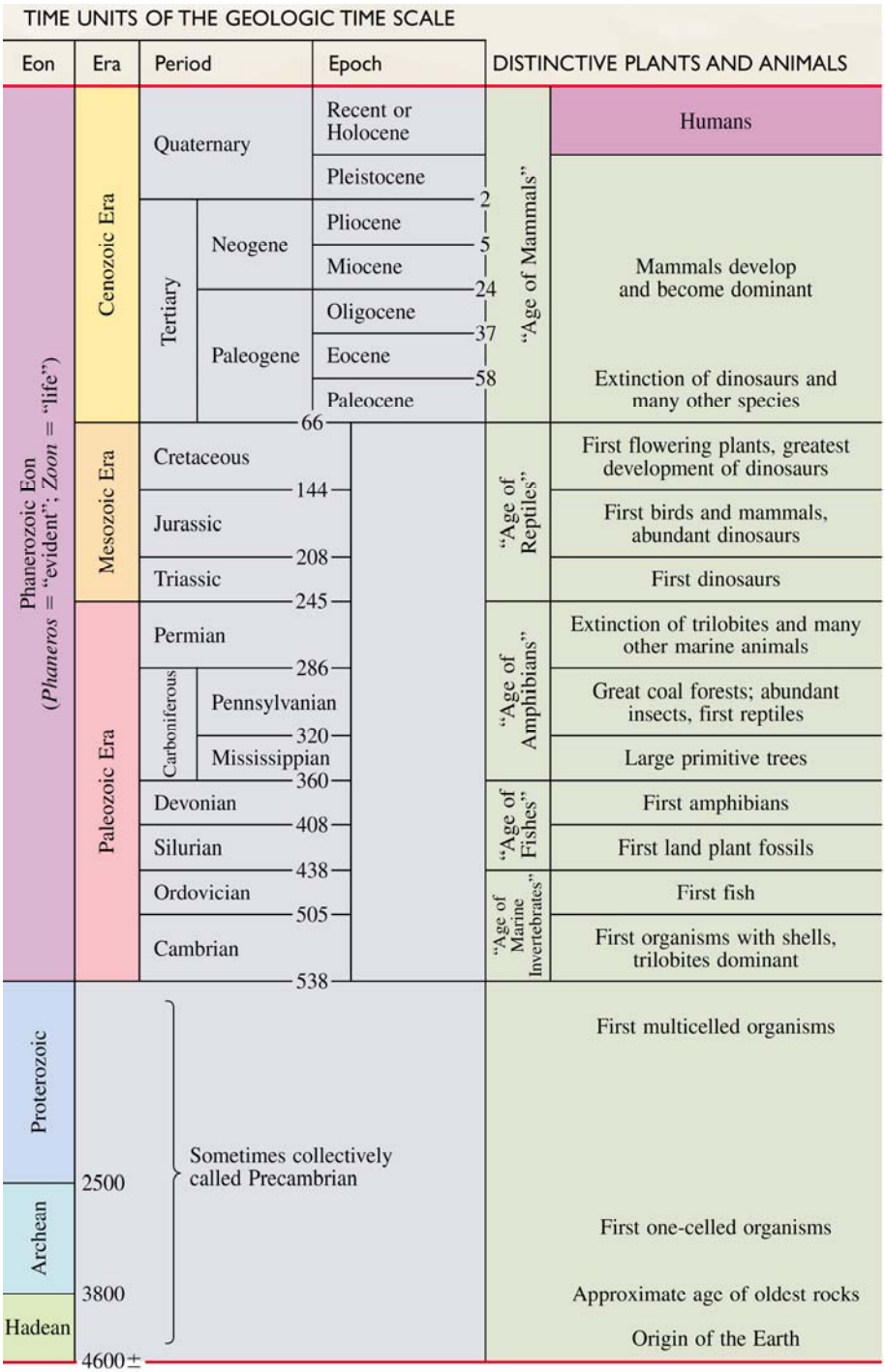
The most recent 13 percent of geologic time, from 538 million years ago to the present, is called the Phanerozoic Eon.

Phanerozoic Eon

The word Phanerozoic is from the Greek, meaning “visible life.” Sedimentary rocks of the Phanerozoic Eon contain abundant and easily recognizable fossils. The beginning of Phanerozoic time marks a dramatic increase in the abundance and diversity of life. Subdivision of the Phanerozoic Eon into three eras is based on the most common types of life during each era. Sedimentary rocks formed during the **Paleozoic era** (Greek for “old life”) contain fossils of early life forms, such as invertebrates, fishes, amphibians, reptiles, ferns, and conebearing trees.

Sedimentary rocks of the **Mesozoic era** (Greek for “middle life”) contain new types of phytoplankton, microscopic plants that float at or near the sea surface, and beautiful, swimming cephalopods called ammonoids.

Table 3-1. The geological time scale.



However, the Mesozoic Era is most famous for the dinosaurs. Mammals and flowering plants also developed during this era.

During the **Cenozoic era** (Greek for "recent life"), mammals and grasses became abundant.

EXERCISES

3.4. According to the passage, which of the following statements are "true" or "false"? Insert "T" or "F" in the boxes at the right.

1. In a disconformity, the sedimentary layers above and below the unconformity are parallel.
2. An unconformity in which sedimentary rocks lie on igneous or metamorphic rocks is called disconformity.
3. Most Proterozoic organisms had hard parts such as shells and bones.
4. Most Proterozoic organisms were single celled.
5. Mesozoic Era is most famous for the ammonoids.
6. The Phanerozoic era subdivided into three eons.

3.5. Choose a, b, c, or d which best completes each item.

1. According to the principle of faunal succession:
   a) fossil species succeed one another in undisturbed rocks in a definite and recognizable order around the world.
   b) most sedimentary rocks and fauna formed as nearly horizontal layers.

c) any layered sequences that are now tilted were moved by later geologic processes.

d) any rock that cross-cuts another rock is younger than the rock it cross-cuts.

2. Which of the eons, cover the first 2.5 billion years of Earth history?
   a) The Hadean and Archean b) The Hadean and Proterozoic
   c) The Archean and Precambrian d) The Archean and Proterozoic
3. Phanerozoic is from the Greek, meaning:
   a) visible life b) middle life
   c) recent life d) old life
4. Ferns, and conebearing trees developed during:
   a) Proterozoic b) Mesozoic
   c) Cenozoic d) Paleozoic
5. …….. concern the actual age of a rock or mineral.
   a) Layered sequences b) Superposition
   c) Absolute age d) Relative age
6. Which eon (or era) started about 538 million years ago?
   a) Proterozoic b) Phanerozoic
   c) Precambrian d) Archean

3.6. Write the answers to the following questions in your own words.

1. Describe the two ways of measuring geologic time. How do they differ?

…….
……
……
……
……
……
……

2. How does the principle of superposition allow us to determine the relative ages of a sequence of unfolded sedimentary rocks?

…….
……
……..……
……..……
……..…
……..…
……..…

3. Explain the principle of crosscutting relationships and how it can be used to determine age relationships among sedimentary rocks.

…….
……
……..……
……..……
……..…
……..…
……..…

4. Explain the differences among unconformities, disconformities, angular unconformities, and nonconformities.

…….
……
……..……
……..……
……..…
……..…
……..…

5. What tools or principles are most commonly used in correlation?

…….
……
……..……
……..……
……..…
……..…
……..…

3.7. Note the following technical words and their definitions and translate the words into Persian.

Technical words	Definitions
Correlate (verb)	establish a mutual relation
Correlation (noun)	showing of the age equivalence of rocks or geologic features from different locations.
Correlatable (adjective)	may be correlated
Correlative (adjective)	mutually related
Correlating	

Now, fill in the blanks with the appropriate words.

1. A sequence is a succession of genetically related relatively conformable strata bounded by unconformities or their ..... conformities.
2. Both marine and continental sediments are ..... with those of the Gondwana deposits which occur in parts of Himalayas.
3. Studies of fossils and of the depositional order of sedimentary layers led to the principles of fossil succession and .....
4. Global ..... for the top of the Cambrian System are not finalized.
5. The main units of paleozoic are ..... for long distances.
6. The geologic history of an area can be reconstructed by ..... rock exposures within the area.
7. Geologists ..... rocks that accumulated continuously through portions of geologic time from many different localities around the world.

3.8. Rearrange the sentence parts of the following table into four different sentences.

most Proterozoic organisms	shows a gap	formed during the history of the Earth.
unconformity	had no hard parts	time correlation
geologic column,	is used for	in deposition
key bed	is a record of rocks	and were single celled

1. ……..…
2. ……
3. ……..…
4. ……..…

3.9. Translate the following passage into Persian.

The longest movie never shown: the Earth's story

One way of trying to imagine geologic time is to compare it to a motion picture. A movie is projected at a rate of sixteen frames per second. It means that each image is flashed on the screen for only one-sixteenth of a second giving a continuous motion. But suppose that each frame represented 100 years. If you lived 100 years, one frame would represent your whole lifetime.

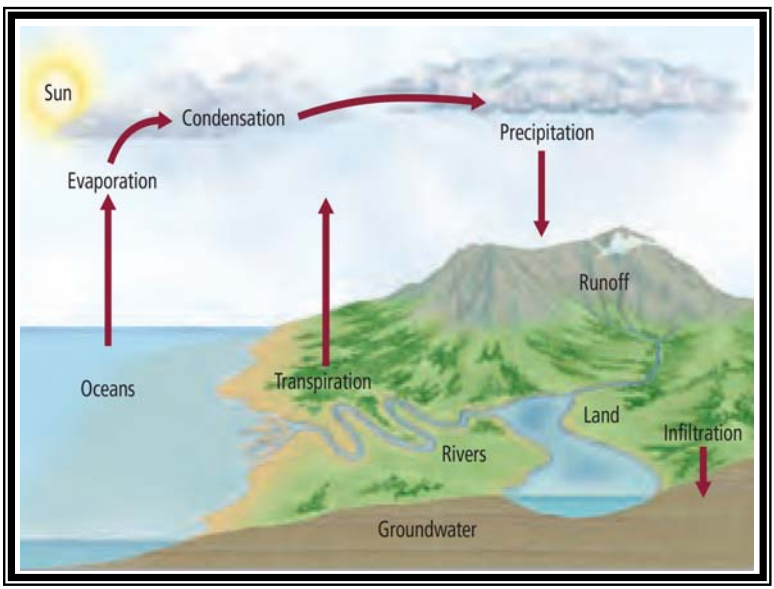
If we were able to show the movie on a standard projector, each 100 years would flash by in one-sixteenth of a second. However, you have to sit through more than eleven hours of film to view the Mesozoic era. And to give a complete record from the beginning of the Paleozoic era, this film would have to run continuously for four days.

You would have to spend over a month (thirty-two and a half days) in the cinema to see a movie entitled "The complete story of earth, from its birth to modern civilization".

From the perspective of that one last frame, geologists would like to know what the whole movie is like or, at least, get a summary of the most dramatic parts of the film.

UNIT 4

HYDROGEOLOGY
AND
THE HYDROLOGICAL CYCLE



هدف کلی

محتوای اصلی این درس که تحت عنوان Hydrogeology and the hydrological science ارائه گردیده است، در خصوص آب‌های سطحی و زیرزمینی و نیز چرخه آب‌ها بحث می‌کند. هدف کلی از تدوین این درس، آشنایی دانشجویان با تعدادی از واژه‌ها و اصطلاحات عمومی و واژه‌های کلیدی زمین‌شناسی و نیز کسب مهارت لازم در درک محتوای متن انگلیسی درس می‌باشد.

هدف‌های رفتاری

انتظار می‌رود دانشجو با مطالعه این فصل بتواند:

۱. معنی واژه‌های عام بخش ۴–۱ را با استفاده از فرهنگ لغات، مشخص نموده و مترادف و متضاد هر یک از واژه‌ها را بیاموزد.

۲. معنی واژه‌های کلیدی و تخصصی بخش ۴–۲ را پس از جستجو در فرهنگ لغات زمین‌شناسی، آموخته و تلفظ صحیح آنها را فرا گیرد.

۳. متن اصلی درس را با دقت مطالعه نموده و درک کلی از مفهوم آب‌های زیرزمینی و فرایندهای دخیل در ایجاد چرخه آب را داشته باشد.

۴. با توجه به مفهوم کلی درس، صحیح یا غلط‌بودن عبارات تمرین ۴–۴ را مشخص نماید.

۵. با توجه به متن درس، در بخش ۴–۵ مناسب‌ترین گزینه را از بین چهار گزینه، انتخاب و علامت‌گذاری نماید.

۶. پاسخ سؤالات بخش ۴–۶ را با توجه به مفهوم کلی درس، مشخص نموده و سعی نماید تا بدون استفاده از جمله‌بندی‌های متن درس، سؤالات را جواب دهد.

۷. اقسام کلام (اسم، فعل، قید و صفت) واژه تخصصی Hydrogeology به همراه تعاریف آنها را آموخته و قادر به به‌کار بردن این واژه‌ها در جملات مختلف تخصصی باشد.

۸. متن انگلیسی بخش ۴–۸ را با واژه‌های داده‌شده تکمیل و سپس آن را به فارسی روان ترجمه نماید.

۹. با توجه به محتوای اصلی درس، در جدول بخش ۴–۹، اصطلاحات به‌کاربرده شده در چرخه آب را با تعاریف آنها جور نماید.

۱۰. مکان‌های خالی نمودار چرخه سنگ‌ها (بخش ۴–۱۰) را با استفاده از واژه‌های داده‌شده تکمیل نماید.

۱۱. جملات پراکنده ارائه‌شده در بخش ۴–۱۱ را با توجه به مفهوم درس، به‌صورت سه جمله کامل بازسازی نماید.

4.1. COMMON WORDS: Note the synonyms and antonyms of following words and translate the words into Persian.

Word	Synonym	Antonym
shift	change in position and direction	keep
eventually	finally	beginning
condense	become liquid	vaporize
lose	miss	find
constant	firm	variable

4.2. TECHNICAL WORDS: Note the pronunciation of the following technical words and expressions and translate them into Persian.

1. hydrogeology ……..
2. hydrological cycle /hў-drŏ-loj-ik/ ……..
3. evaporite /i-vap-ŏ-rўt/ ……..
4. aquifer ……..
5. runoff ……..
6. precipitation /pri-sip-ă-tay-shŏn/ ……..
7. infiltration ……..
8. joint ……..
9. pore space ……..
10. transpiration ……..
11. sublimation /sub-lă-may-shŏn/ ……..
12. condensation ……..

4.3. Reading

HYDROGEOLOGY AND THE HYDROLOGICAL CYCLE

What is hydrogeology?

Hydrogeology is the scientific study of water movements on and

below the Earth's surface. It is an area of geology that deals with the distribution and movement of **groundwater** in the soil and rocks of the Earth's crust, (commonly in **aquifers**). The study of the interaction between groundwater movement and geology can be quite complex. Groundwater does not always flow in the subsurface down-hill following the surface topography; groundwater follows **pressure gradients** (flow from high pressure gradient to low) often following fractures and conduits in circuitous paths.

Water on or beneath Earth's surface cycles among the various reservoirs: the oceans, the atmosphere, and the land. These water movements can be illustrated and described in a **water** or **hydrological cycle.** Water evaporates from the oceans and is carried in the air from the sea over the land, which receives it as precipitation, and finally returns from the land to the sea through rivers, thus completing the cycle (Fig. 4-1). However, it is also stored in the biosphere as organisms use water, - for example, within the trees of rain forests.

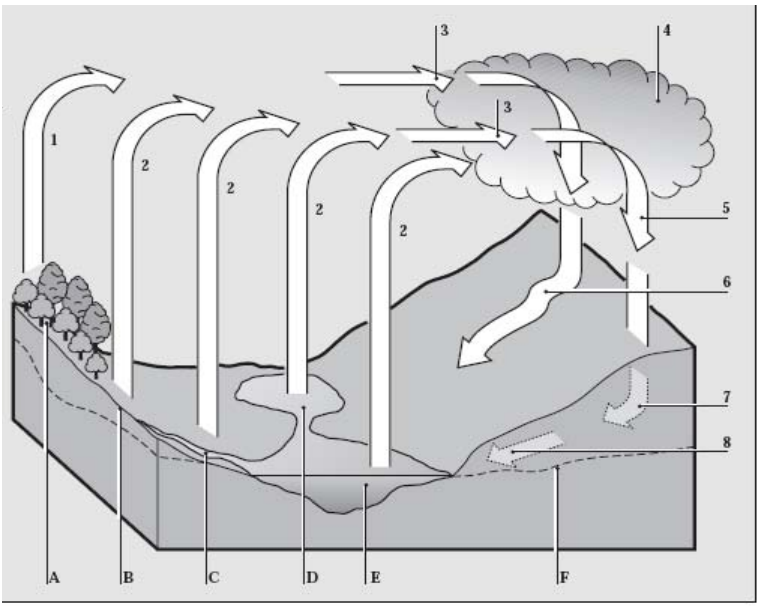


Fig. 4-1. The hydrologic cycle. 1=Evapotranspiration, 2= Evaporation, 3= Transportation, 4= Condensation, 5= Precipitation, 6= Surface runoff, 7= Infiltration, 8= Ground water flow, A= Vegetation, B= Soil, C= Streams, D= Lakes, E= Oceans, F= Water table.

The hydrological cycle

Within the range of temperatures found at Earth's surface, water shifts among the three states of matter: liquid (water), gas (water vapor), and solid (ice). These transformations power some of the main flows from one reservoir to another in the hydrologic cycle.

Earth's external heat engine, powered by the Sun, drives the hydrologic cycle, mainly by **evaporating water** from the oceans and transporting it as **water vapor** in the atmosphere.

Under the right conditions of temperature and humidity, water vapor condenses to the tiny droplets of water that form clouds and eventually falls as rain or snow - together known as precipitation - over the oceans and continents.

Some of the water that falls on land penetrates into the ground by **infiltration**, the process by which water enters rock or soil through joints or small **pore spaces** between particles. Part of this groundwater **evaporates** through the soil surface. Another part is **absorbed** by the biosphere in plant roots, carried up to the leaves, and returned to the atmosphere by **transpiration** - the release of water vapor from plants. Other groundwater may return to the surface in springs that empty into rivers and lakes.

The rainwater that does not infiltrate the ground runs off the surface, gradually collecting into streams and rivers. The sum of all rainwater that flows over the surface, and then flow back to the surface, is called **runoff**. Some runoff may later seep into the ground or evaporate from rivers and lakes, but most of it flows into the oceans.

Snowfall may be converted into ice in glaciers, which return water to the oceans by melting and runoff and to the atmosphere by **sublimation**, the transformation from a solid (ice) directly into a gas (water vapor). Most of the water that evaporates from the oceans returns to them as **precipitation**. The remainder falls over the land and either evaporates or returns to the ocean as runoff.

The land surface gains water from precipitation and loses the same amount of water by evaporation and runoff. The ocean gains water from runoff and precipitation and loses the same amount by

evaporation. More water evaporates from the oceans than falls on them as rain. This loss is balanced by the water returned as runoff from the continents. Thus, the size of each reservoir stays constant.

EXERCISES

4.4. According to the passage, which of the following statements are "true" or "false"? Insert "T" or "F" in the boxes at the right.

1. Most of the water that evaporates from the oceans returns to them as infiltration.
2. Most of runoff flows into the oceans.
3. The hydrologic cycle drives the Sun.
4. The release of water vapor from plants is named precipitation.

4.5. Choose a, b, c, or d which best completes each item.

1. What is called the sum of all rainwater that flows over the surface, and then flow back to the surface?
   a) infiltration b) precipitation
   c) evaporation d) runoff
2. What is the process by which water enters rock or soil through joints or small pore spaces between particles?
   a) infiltration b) precipitation
   c) evaporation d) runoff
3. What is named the transformation from a solid directly into a gas?
   a) sublimation b) precipitation
   c) evaporation d) infiltration
4. The ocean loses water by ……..

a) precipitation b) evaporation
c) infiltration d) runoff

4.6. Write the answers to the following questions in your own words.

1. What are the three states of water?

……
……
……
……
……
……
……

2. What is the infiltration?

……
……
……
……
……
……
……

4.7. Note the following technical words and their definitions and translate the words into Persian.

Technical words	Definitions
Hydrogeology (noun)	The science that deals with subsurface waters and with related geologic aspects of surface waters.
Hydrogeologist (noun)	A geologist which study the ground water.
Hydrogeologic (adjective)	relating to hydrogeology.
Hydrogeological (adjective)	relating to hydrogeology.

Now, fill in the blanks with the appropriate words.

1. Engineering geologists can detect and describe geological, ..., and topographical conditions
2. ..... concerns the character of fluids (water and gas) within the ground.
3. Many geological engineers and engineering geologists are specializing in water-related topics, commonly considered the realm of .....
4. Mixing processes are very important in ..... systems.
5. ..... deal with the crucial area of the movement of groundwater and our ability to provide clean water to society.
6. Many ..... investigations were carried in Asia during the past decades.
7. ..... properties of rocks and soils are very important for .....

4.8. Fill in the blanks with the following words and translate the passage into Persian.

"groundwater", "transported", "transportation" "runoff", "condenses", "precipitation", "evaporation"

The ……**1**……. cycle begins with the ……**2**……. of water from the surface of the ocean. As moist air is lifted, it cools and water vapor ……**3**……. to form clouds. Moisture is ……**4**……. around the globe until it returns to the surface as ……**5**……. Once the water reaches the ground, one of two processes may occur; first some of the water may evaporate back into the atmosphere or second the water may penetrate the surface and become ……**6**……. Groundwater either seeps its way to into the oceans, rivers, and streams, or is released back into the atmosphere through ……**7**…….

.....
.....
.....
.....
.....
.....
.....
.....
.....

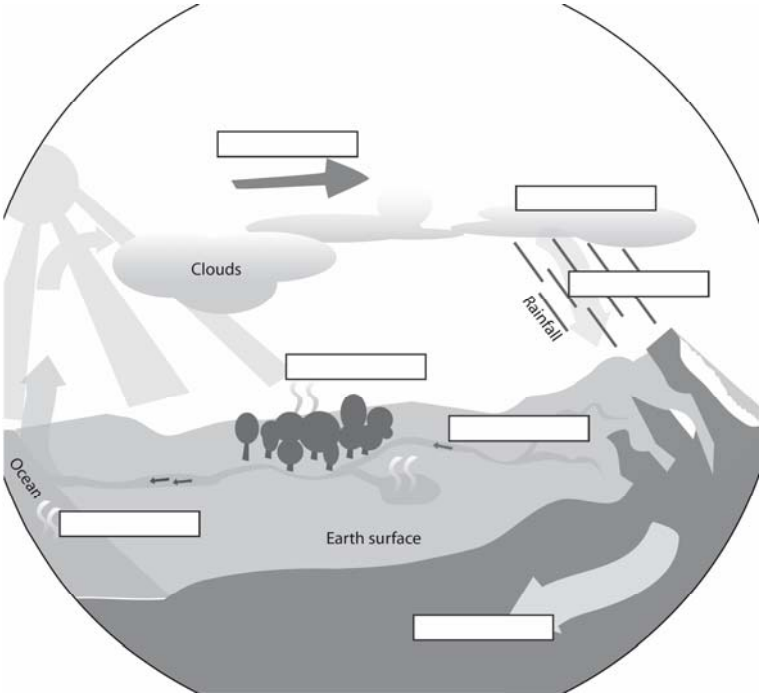
.....

4.9. Match the terms to their definitions.

Terms	Definitions
1. Condensation	A) From the smallest streams to rivers etc. that move water from land to the oceans.
2. Evaporation	B) The transformation of water from gas into a liquid.
3. Groundwater	C) Transfer of water to the atmosphere by plants and vegetation.
4. Precipitation	D) The transfer of water from the atmosphere to land. Rain, snow, hail, sleet, and freezing rain are different types of it.
5. Runoff	E) The movement of water through the atmosphere.
6. Transpiration	F) The transformation of water from a liquid into a gas.
7. Transport	G) Water below the surface and its location in different soil layers and gaps.

1—— 2—— 3—— 4—— 5—— 6—— 7——

4.10. Label the simplified version of a water cycle with the above mentioned terms of part D.



4.11. Form three separate sentences from the sentence parts.

to evaporate from oceans	produces clouds	causes water
condensation	remains constant	heat from the sun
of tiny droplets of water	on earth	the amount of water

1. ……
2. ……
3. ……

UNIT 5

MINERALOGY I
Mineral Properties

هدف کلی

محتوای اصلی این درس که تحت عنوان Mineralogy, mineral properties ارائه گردیده است، در رابطه با خصوصیات تشخیصی کانی‌ها بحث می‌کند. هدف کلی از تدوین این درس، آشنایی دانشجویان با تعدادی از واژه‌ها و اصطلاحات عمومی و واژه‌های کلیدی زمین‌شناسی و نیز کسب مهارت لازم در درک محتوای متن انگلیسی درس می‌باشد.

هدف‌های رفتاری

انتظار می‌رود دانشجو با مطالعه این فصل بتواند:

۱. معنی واژه‌های عام بخش ۵-۱ را با استفاده از فرهنگ لغات، مشخص نموده و مترادف و متضاد هر یک از واژه‌ها را بیاموزد.
۲. معنی واژه‌های کلیدی و تخصصی بخش ۵-۲ را پس از جستجو در فرهنگ لغات زمین‌شناسی، آموخته و تلفظ صحیح آنها را فرا گیرد.
۳. متن اصلی درس را با دقت مطالعه نموده و درک کلی از تعریف کانی و خصوصیات به‌کار برده‌شده جهت تشخیص آنها داشته باشد.
۴. با توجه به مفهوم کلی درس، صحیح یا غلط‌بودن عبارات تمرین ۵-۴ را مشخص نماید.
۵. با توجه به متن درس، در بخش ۵-۵ مناسب‌ترین گزینه را از بین چهار گزینه، انتخاب و علامت‌گذاری نماید.
۶- پاسخ سؤالات بخش ۵-۶ را با توجه به مفهوم کلی درس، مشخص نموده و سعی نماید تا بدون استفاده از جمله‌بندی‌های متن درس، سؤالات را جواب دهد.
۷- اقسام کلام (اسم، فعل، قید و صفت) واژه تخصصی Mineral به همراه تعاریف آنها را آموخته و قادر به به‌کار بردن این واژه‌ها در جملات مختلف تخصصی باشد.
۸. متن انگلیسی بخش ۵-۸ را با واژه‌های داده‌شده تکمیل و سپس آن را به فارسی روان ترجمه نماید.
۹. در مقابل تعاریف اصطلاحات به‌کاربرده شده در مورد خصوصیات تشخیصی کانی‌ها (بخش ۵-۹)، واژه مورد نظر را انتخاب و در جای خالی قرار دهد.

5.1. COMMON WORS: Note the synonyms and antonyms of following words and translate the words into Persian.

Word	Synonym	Antonym
distinctive	special	common
cloudy	indistinct	clear
translucent	transparent	opaque
alter	change	preserve
reliable	dependable	untrustworthy
shiny	reflecting light	matt
dull	cloud	bright
smooth	not rough, polished	uneven, rough
rapidly	quickly	slowly
emit	send out	absorb
exposed	without covering or protection	cover
customarily	usually	occasionally
extend	enlarge	shorten
tiny	very small	huge

5.2. TECHNICAL WORDS: Note the pronunciation of the following technical words and expressions and translate them into Persian.

1. crystal habit ……..
2. crystalline /kris-tă-lin, -lÿn/ ……..
3. mineralization /min-ĕ-ră-lă-zay-shŏn/ ……..
4. Mohs hardness scale /mohz/ ……..
5. Talc /tal’k/ ……..
6. corundum ……..
7. cleavage ……..
8. hardness ……..
9. colour ……..
10. translucent ……..
11. ruby ……..

12. sapphire ……..
13. streak ……..
14. luster ……..
15. metallic ……..
16. shiny ……..
17. glassy ……..
18. vitreous ……..
19. dull ……..
20. fracture ……..
21. conchoidal fracture /kon-koi-dăl/ ……..
22. magnetism ……..
23. radioactivity ……..
24. fluorescence /floo-ŏ-ress-ĕns/ ……..
25. phosphorescence ……..
26. scintillometer ……..
27. fibrous fragments ……..
28. specific gravity ……..

5.3. Reading

MINERALOGY I "Mineral Properties"

What is a mineral?

A naturally occurring substance with a characteristic chemical composition expressed by a chemical formula; may occur as individual crystals or may be disseminated in some other mineral or rock. Most mineralogists include the requirements of inorganic origin and internal crystalline structure.

Minerals are the building blocks of the Earth. For example, SiO_2 is always the mineral quartz which consists of only two elements. A few elements - carbon, for example - are the only components of minerals. Graphite and diamond are composed only of carbon, each with a different architecture. A rock is a solid material that is

composed of various minerals.

Chemical composition and crystalline structure are the two most important properties of a mineral. They distinguish any mineral from all others.

Physical properties of minerals

How does a geologist identify a mineral in the field?

It is often difficult to identify a mineral simply by looking at it, but each mineral has a set of distinctive characteristics that are easily tested in the field or laboratory. Geologists commonly use physical properties such as crystal habit, cleavage, and hardness to identify minerals.

Hardness

Hardness is a distinctive quality of minerals that is determined by the Mohs hardness scale. Talc is the softest mineral on the scale at a value of 1, and diamond is the hardest at a value of 10 (Table 5-1). Geologists often scratch minerals with a knife blade that has a hardness of about 5. If the mineral scratches the knife, it is harder than 5; if the mineral is scratched, its hardness is less than 5. A thumbnail is about 2.5 on the Mohs scale.

Table 5-1 Mohs' hardness scale of mineral hardness: A method of identifying minerals.

Hardness	Mineral	Formula	Absolute Hardness
1	Talc	$Mg_3Si_4O_{10}(OH)_2$	1
2	Gypsum	$CaSO_4.2H_2O$	2
3	Calcite (=Kalkspar)	$CaCO_3$	9
4	Fluorite (=Fluorspar)	CaF_2	21
5	Apatite	$Ca_5(PO_4)3(OH^-, Cl^-, F^-)$	48
6	Orthoclase Feldspar	$KAlSi_3O_8$	72
7	Quartz	SiO_2	100
8	Topaz	$Al_2SiO_4(OH^-, F^-)_2$	200
9	Corundun	Al_2O_3	400
10	Diamond	C	1500

Color

Color is the most obvious property of a mineral, but it is commonly

unreliable for identification. Color would be a reliable identification tool if all minerals were pure and had perfect crystal structures. However, both small amounts of chemical impurities in crystal structure can alter color. For example, corundum (Al_2O_3) is normally a cloudy, translucent, brown or blue mineral. Addition of a small amount of chromium can convert corundum to the beautiful, clear, red gem known as ruby. A small quantity of iron or titanium turns corundum into the striking blue gem called sapphire.

Streak

Streak is the color of a fine powder of a mineral. It is observed by rubbing the mineral across a piece of unglazed porcelain known as a streak plate. Many minerals leave a streak of powder with a diagnostic color on the plate. Streak is commonly more reliable than the color of the mineral itself for identification.

Luster

The luster is the appearance of the light that is reflected from a mineral's surface. Luster can be metallic (shiny), glassy or vitreous, or earthy (dull, not shiny).

Crystal form

Sometimes minerals have a distinctive crystal form that reflects a specific internal arrangement of atoms. The crystal form is best developed when the mineral can crystallize slowly from the fluid that contains its elements.

Cleavage

Cleavage is the tendency of a mineral to break along preferred crystalline planes that are weakly bonded. The angle between various crystal faces is often distinctive for different mineral groups and can be determined with a magnifying lens in the field.

Fracture

Fracture is the pattern in which a mineral breaks other than along planes of cleavage. Many minerals fracture into characteristic shapes. Conchoidal fracture creates smooth, curved surfaces (Fig. 5–1). It is characteristic of quartz and olivine. Glass, although not a mineral because it has no crystalline structure, also typically fractures in a conchoidal pattern. Some minerals break into fibrous fragments. Most minerals fracture into irregular shapes.

Figure 5–1. Quartz typically fractures along smoothly curved surfaces, called conchoidal fractures. This sample is smoky quartz.

Specific gravity

Specific gravity is the weight of a substance relative to that of an equal volume of water. If a mineral weighs 2.5 times as much as an equal volume of water, its specific gravity is 2.5. You can estimate a mineral's specific gravity simply by hefting a sample in your hand. If you practice with known minerals, you can develop a feel for specific gravity. Most common minerals have specific gravities of about 2.7. Metals have much greater specific gravities; for example, gold has the highest specific gravity of all minerals, 19. Lead is 11.3, silver is 10.5, and copper is 8.9.

Other properties

Properties such as reaction to acid, magnetism, radioactivity, fluorescence, and phosphorescence can be characteristic of specific minerals. Calcite and some other carbonate minerals dissolve rapidly in acid, releasing visible bubbles of carbon dioxide gas. Minerals

containing radioactive elements such as uranium emit radioactivity that can be detected with a scintillometer. Fluorescent materials emit visible light when they are exposed to ultraviolet light.

EXERCISES

5.4. According to the passage, which of the following statements are "true" or "false"? Insert "T" or "F" in the boxes at the right.

1. Minerals are artificial substances with a characteristic crystal structure.
2. Hardness of a knife blade is about 5.
3. Sapphire and ruby have similar composition.
4. Glass is a mineral.
5. Conchoidal fracture is characteristic of quartz and olivine.
6. Lead has more specific gravity than the gold.
7. Scintillometer is used for detection of phosphorescence property in minerals.
8. Color is commonly more reliable than the streak of the mineral itself for identification.

5.5. Choose a, b, c, or d which best completes each item.

1. Geologists can distinguish any mineral from all others by chemical composition and ……..

a) specific gravity b) crystalline structure
c) physical properties d) color and streak

2. What is named the tendency of some minerals to break along flat surfaces?
   a) fracture b) cleavage
   c) crystal shape d) hardness
3. A small quantity of iron or titanium turns corundum into the ……..
   a) Ruby b) glass
   c) spinel d) sapphire
4. …….. materials emit visible light when they are exposed to ultraviolet light.
   a) Silicate b) Radioactive
   c) Fluorescent d) Conchoidal
5. The equivalent name for shiny luster is ……..
   a) metallic b) dull
   c) vitreous d) glassy

5.6. Write the answers to the following questions in your own words.

1. If you were given a crystal of diamond and another of quartz, how would you tell which is diamond?

…….
……
……..……
……..……
……..…
……..…
……..…

2. List and explain the physical properties of minerals most useful for identification.

…….

……
……
……
……
……
……

3. Why do some minerals have cleavage and others do not?

……
……
……
……
……
……
……

4. Why is color often an unreliable property for mineral identification?

……
……
……
……
……
……
……

5.7. Note the following technical words and their definitions and translate the words into Persian.

Technical words	Definitions
Mineral (noun)	natural substance belonging to a group of inorganic (often crystalline) compounds which are found in the earth
Mineralogy (noun)	branch of science dealing with minerals and classification of minerals

Mineralization (noun)	transformation into mineral form
Mineralogic (adjective)	pertaining to mineralogy
Mineralogical (adjective)	of the study of minerals, of mineralogy
Minralogically (adverb)	according to the study of minerals
Mineralize (verb)	transform into mineral form
Mineralogist (noun)	A geologist whose field of study is mineralogy

Now, fill in the blanks with the appropriate words.

1. ....., saline ground waters have been pumped to the surface during earthquakes.
2. It is clear that the ..... of igneous rocks have crystallized out of a melt.
3. Chemical sediments are subdivided into several groups by ..... composition.
4. Two parameters are used to name and classify sandstones: chemical ..... and physical texture.
5. Granites ..... composed of quartz and feldspar.
6. ....., pure chalks are composed of low magnesium calcite.
7. Manganese ..... occur in oceans.
8. The ..... maturity of sandstones is commonly expressed by the quartz/feldspar ratio.
9. When igneous rocks undergo deep burial, ... and textural changes occur as they metamorphose.
10. To the ....., ‘clay’ is the term describing a ..... family characterized by its crystal structure.

5.8. Fill in the blanks with the following words and translate the passage into Persian.

“cleavage”, “crystal form”, “colorless”, “hardness”, “glass”, “grains”, “luster” and “pyramid”.

The Silicate "Quartz"

Its chemical formula is SiO2. Quartz has a vitreous ……**1**……., a ……**2**……. of 7, and when pure, is completely clear and ……**3**……. It looks like frozen water. It lacks ……**4**……., but it commonly fractures conchoidally. Should quartz grow free from interferences it crystallizes customarily in a six-sided ……**5**……., which is terminated by a sharp-pointed pyramid at each end. If quartz grows into cavities, as it commonly grows, it will possess only one ……**6**……. on the end of crystal that extends into the opening. Crystal that grows into openings may sometimes reach length of 0.3 m or more. Usually quartz occurs in association with other minerals as tiny ……**7**……. two to three millimeters across that generally lack crystal faces. Where fresh and unweathered the disseminated grains often sparkle like tiny fragments of ……**8**…….

.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....

5.9. The most common minerals can be identified by "luster", "hardness", "cleavage and fracture", "color and streak", "transparency", "magnetism", "specific gravity or density" and "crystal form".
Match the definitions or description to the properties.

1. ..... is the property of breaking easily at random lines.
2. ..... is the measure of the ease with which the surface of a mineral can be scratched.
3. ..... is the characteristic of a mineral that tells how the mineral reflects light, i.e. how shiny it is.
4. ..... is the characteristic that tells you if you can see through it.
5. ..... can be seen; i.e. it is visual perception.
6. ..... is the shape in which the individual crystals grow.
7. ..... is the splitting of minerals along planes.
8. ..... the color of a mineral under the top layer or coating of the mineral.
9. ..... is the property of a mineral which depends on the atomic weight.
10. ..... if a mineral has this property, it contains a high quantity of iron.

UNIT 6

MINERALOGY II
Classification of minerals

هدف کلی

محتوای اصلی این درس که تحت عنوان Mineralogy, classification of minerals ارائه گردیده است، در خصوص آشنایی با گروه‌های مختلف کانی‌ها می‌باشد. هدف کلی از تدوین این درس، آشنایی دانشجویان با تعدادی از واژه‌ها و اصطلاحات عمومی و واژه‌های کلیدی زمین‌شناسی و نیز کسب مهارت لازم در درک محتوای متن انگلیسی درس می‌باشد.

هدف‌های رفتاری

انتظار می‌رود دانشجو با مطالعه این فصل بتواند:

۱. معنی واژه‌های عام بخش ۶–۱ را با استفاده از فرهنگ لغات، مشخص نموده و مترادف و متضاد هر یک از واژه‌ها را بیاموزد.
۲. معنی واژه‌های کلیدی و تخصصی بخش ۶–۲ را پس از جستجو در فرهنگ لغات زمین‌شناسی، آموخته و تلفظ صحیح آنها را فرا گیرد.
۳. متن اصلی درس را با دقت مطالعه نموده و درک کلی از معیارهای تقسیم‌بندی کانی‌ها و انواع گروه‌های کانی‌ها داشته باشد.
۴. با توجه به مفهوم کلی درس، صحیح یا غلط‌بودن عبارات تمرین ۶–۴ را مشخص نماید.
۵. با توجه به متن درس، در بخش ۶–۵ مناسب‌ترین گزینه را از بین چهار گزینه، انتخاب و علامت‌گذاری نماید.
۶. پاسخ سؤالات بخش ۶–۶ را با توجه به مفهوم کلی درس، مشخص نموده و سعی نماید تا بدون استفاده از جمله‌بندی‌های متن درس، سؤالات را پاسخ دهد.
۷. اقسام کلام (اسم، فعل، قید و صفت) واژه تخصصی Crystal به همراه تعاریف آنها را آموخته و قادر به به‌کار بردن این واژه‌ها در جملات مختلف تخصصی باشد.
۸. متن انگلیسی بخش ۶–۸ را با واژه‌های داده شده تکمیل و سپس آن را به فارسی روان ترجمه نماید.
۹. با استفاده از متن درس، جدول بخش ۶–۹ را تکمیل نماید.

6.1. COMMON WORDS: Note the synonyms and antonyms of following words and translate the words into Persian.

Word	synonym	antonym
simple	uncomplicated	complex
abundant	plentiful	scarce
synthetic	artificial, man-made	natural
important	significant	trivial, insignificant
native	endemic	combined
similar	alike	different
independent	free	related

6.2. TECHNICAL WORDS: Note the pronunciation of the following technical words and expressions and translate them into Persian.

1. native element ……..
2. insecticide ……..
3. fertilizer ……..
4. rubber ……..
5. complex anion ……..
6. industrial sulfates ……..
7. plaster ……..
8. evaporation ……..
9. polymorph ……..
10. silicon ……..
11. silicate /sil-ă-kayt, -kit/ ……..
12. tetrahedron ……..
13. tetrahedral ……..
14. single-chain silicates ……..
15. double-chain silicate ……..
16. sheet silicates ……..
17. adamantine /ad-ă-man-tin, -teen, -tÿn/ ……..
18. waxy ……..

19. transparency ……..
20. translucent ……..
21. rough crystals ……..
22. isometric ……..
23. crystal system ……..
24. twinning ……..
25. hematite /hem-ă-tÿt, hee-mă-/ ……..
26. magnetite /mag-nĕ-tÿt/ ……..
27. spinel /spi-nel/ ……..
28. pyrite /pÿ-rÿt/ ……..
29. chalcopyrite /kal-kŏ-pÿ-rÿt/ ……..
30. galena /gă-lee-nă/ ……..
31. sphalerite /sfal-ĕ-rÿt/ ……..
32. anhydrite /an-hÿ-drÿt/ ……..
33. apatite /ap-ă-tÿt/ ……..
34. calcite /kal-sÿt/ ……..
35. dolomite /dol-ŏ-mÿt/ ……..
36. aragonite /a-ră-gŏ-nÿt/ ……..
37. olivine /ol-ă-veen, ol-ă-veen/ ……..
38. pyroxene /pÿ-roks-een/ ……..
39. amphibole /am-fă-bohl/ ……..
40. feldspar /feld-spar, fel-/ ……..
41. quartz /kwort-s/ ……..
42. kimberlite /kim-ber-lÿt/ ……..
43. dispersion ……..
44. refractive index ……..

6.3. Reading

MINERALOGY II "Classification of minerals"

Mineral Classification

Geologists classify minerals according to their anions (negatively

charged ions). Anions can be either simple (such as O^{2-}) or Complex (such as $[SiO_4]^{4-}$). Each mineral group (except the native elements) is named for its anion. For example, the oxides all contain O^{2-}, the silicates contain $(SiO_4)^{4-}$, and the carbonates contain $(CO_3)^{2-}$.

Native elements

About 20 elements occur naturally in their native states as minerals. Fewer than ten, however, are common enough to be of economic importance. Gold, silver, platinum, and copper are all mined in their pure forms. Iron is rarely found in its native state in the Earth's crust. Native iron and nickel are thought to comprise most of the Earth's core. Native sulfur, used to manufacture sulfuric acid, insecticides, fertilizer, and rubber. Pure carbon occurs as both graphite and diamond.

Oxides

The oxides are a large group of minerals in which oxygen is combined with one or more metals. Oxide minerals are the most important ores of iron, manganese, tin, chromium, uranium, titanium, and several other industrial metals. Hematite (iron oxide, Fe_2O_3) occurs widely in many types of rocks and is the most abundant ore of iron.

Magnetite (Fe_3O_4), a naturally magnetic iron oxide, is another ore of iron. Spinel ($MgAl_2O_4$) often occurs as attractive red or blue crystals that are used as inexpensive, semiprecious gems. Synthetic spinels are also commonly used in jewelry. Ice, the oxide of hydrogen (H_2O), is a common mineral at the Earth's surface.

Sulfides

Sulfide minerals consist of sulfur combined with one or more metals. Many sulfides are extremely important ore minerals. They are the world's major sources of copper, lead, zinc, molybdenum, silver, cobalt, mercury, nickel, and several other metals. The most common sulfides are pyrite (FeS_2), chalcopyrite ($CuFeS_2$), galena (PbS), and sphalerite (ZnS).

Sulfates

The sulfate minerals contain the sulfate complex anion $(SO_4)^{2-}$. Gypsum ($CaSO_4$-$2H_2O$) and anhydrite ($CaSO_4$) are two important industrial sulfates used to manufacture plaster. Both, form by evaporation of seawater or salty lake water.

Phosphates

Phosphate minerals contain the complex anion $(PO_4)^{3-}$. Apatite, $Ca_5(F,Cl,OH)(PO_4)_3$, is the substance that makes up both teeth and bones.

Carbonates

The complex carbonate anion $(CO_3)^{2-}$ is the basis of two common rock-forming minerals, calcite ($CaCO_3$) and dolomite [$Ca,Mg(CO_3)_2$]. Most limestone is composed of calcite, and dolomite makes up the similar rock that is also called dolomite or sometimes dolostone. Limestone is mined as a raw part of cement. Aragonite is a polymorph of calcite that makes up the shells of many marine animals.

Silicates

The silicate minerals contain the $(SiO_4)^{4-}$ complex anion. Silicates make up about 95 percent of the Earth's crust. To understand the silicate minerals, remember four principles:

1. Every silicon atom surrounds itself with four oxygens. The bonds between each silicon and its four oxygens are very strong.
2. The silicon atom and its four oxygens form a pyramid-shaped structure called the **silicate tetrahedron** with silicon in the center and oxygens at the four corners (Fig. 6-1). The silicate tetrahedron has a 4^- charge and forms the $(SiO_4)^{4-}$ complex anion. The silicate tetrahedron is the fundamental building block of all silicate minerals.
3. To make silicate minerals electrically neutral, other cations must combine with the silicate tetrahedra to balance their negative charges.
4. Silicate tetrahedra commonly link together by sharing oxygens. Thus,

two tetrahedra may share a single oxygen, bonding the tetrahedra together.

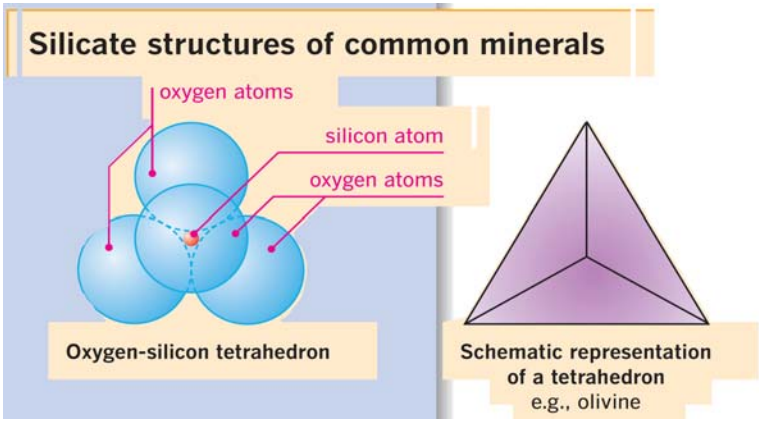


Figure 6-1. The silicate tetrahedron consists of one silicon atom surrounded by four oxygens. It is the fundamental building block of all silicate minerals.

Rock-forming silicate minerals

The rock-forming silicates (and most other silicate minerals) fall into five classes, based on five ways in which tetrahedra share oxygens (Fig. 6-2). Each class contains at least one of the rock-forming mineral groups.

1. In independent tetrahedra silicates, adjacent tetrahedral do not share oxygens (Fig. 6-2A). **Olivine** is an independent tetrahedra mineral that occurs in small quantities in basalt of both continental and oceanic crust. However, rocks composed mostly of olivine and pyroxene is thought to make up most of the mantle.
2. In the single-chain silicates, each tetrahedron links to two others by sharing oxygens, forming a continuous chain of tetrahedra (Fig. 6-2B). The **pyroxenes** are a group of similar minerals with single chain structures. Pyroxenes are a major component of both oceanic crust and the mantle and are also abundant in some continental rocks.
3. The double-chain silicates consist of two single chains crosslinked by the sharing of additional oxygens between them (Fig. 6-2C). The **amphiboles** are a group of double-chain silicates with similar properties.
4. In the sheet silicates, each tetrahedron shares oxygens with three others in the same plane, forming a continuous sheet (Fig. 6-2D).

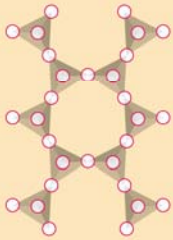
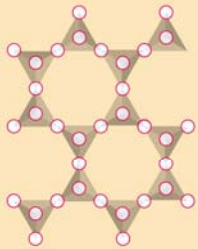
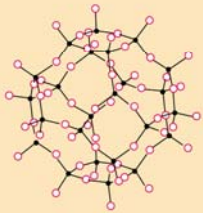
Class	Arrangement of SiO_4 tetrahedron	Unit composition	Mineral examples
A Independent tetrahedra		$(SiO_4)^{4-}$	Olivine: The composition varies between Mg_2SiO_4 and Fe_2SiO_4.
B Single chains		$(SiO_3)^{2-}$	Pyroxene: The most common pyroxene is augite, $Ca(Mg, Fe, Al)\ (Al, Si)_2O_6$.
C Double chains		$(Si_4O_{11})^{6-}$	Amphibole: The most common amphibole is hornblende, $NaCa_2(Mg, Fe, Al)_5(Si, Al)_8O_{22}(OH)_2$.
D Sheet silicates		$(Si_2O_5)^{2-}$	Mica, clay minerals, chlorite, e.g.: muscovite $KAl_2(Si_3Al)O_{10}(OH)_2$
E Framework silicates		SiO_2	Quartz: SiO_2 Feldspar: As an example, potassium feldspar is $KAlSi_3O_8$.

Figure 6-2. The five silicate structures are based on sharing of oxygens among silicate tetrahedra. **(A)** Independent tetrahedra share no oxygens. **(B)** In single chains, each tetrahedron shares two oxygens with adjacent tetrahedra, forming a chain. **(C)** A double chain is a pair of single chains that are crosslinked by additional oxygen sharing. **(D)** In the sheet silicates, each tetrahedron shares three oxygens with adjacent tetrahedra. **(E)** A three-dimensional silicate framework shares all four oxygens of each tetrahedron.

All of the atoms within each sheet are strongly bonded, but each sheet is only weakly bonded to those above and below. Therefore, sheet silicates have excellent cleavage. The **micas** are sheet silicates and typically grow as plate-shaped crystals, with flat surfaces. Mica is common in continental rocks.

5. In the framework silicates, each tetrahedron shares all four of its oxygens with adjacent tetrahedra (Fig. 6-2E). **Feldspar** and **quartz** have framework structures.

EXERCISES

6.4. According to the passage, which of the following statements are "true" or "false"? Insert "T" or "F" in the boxes at the right.

1. Ice is a mineral.
2. Geologists classify minerals according to their structures.
3. Spinel is the most abundant ore of iron.
4. The amphiboles are a group of double-chain silicates.
5. Most of the mantle composed mostly of olivine and pyroxene.
6. Iron is mined in its pure form.
7. Sulfates are the world's major sources of copper, lead and zinc.

6.5. Choose a, b, c, or d which best completes each item.

1. What is an essential fertilizer in modern agriculture?
   a) Apatite b) Phosphate

c) Sulfate d) Sulfide

2. What does make up the shells of many marine animals?
   a) Calcite b) Dolostone
   c) Aragonite d) Dolomite
3. The structures and compositions of silicate minerals are based on the silicate ……..
   a) tetrahedron b) form
   c) formula d) characteristics
4. Which of the following minerals form by evaporation of seawater or salty lake water?
   a) calcite b) dolomite
   c) gypsum d) phosphates
5. Which of the following mineral groups aren't named for their anion?
   a) silicates b) native elements
   c) non silicates d) rock forming minerals
6. Which of the following minerals make up most of the mantle?
   a) quartz and feldspar b) native Iron and Nickel
   c) olivine and pyroxene d) Amphibole and feldspar

6.6. Write the answers to the following questions in your own words.

1. What does the chemical formula for quartz, SiO2, tell you about its chemical composition?

…….
……
……..……
……..……
……..…
……..…
……..…

2. Draw a three-dimensional view of a single silicate tetrahedron. Draw the five different arrangements of tetrahedral found in the

rock-forming silicate minerals. How many oxygen ions are shared between adjacent tetrahedral in each of the five configurations?

……
……
……
……
……
……
……

3. List the rock-forming mineral groups. Why are they called “rock-forming”? Which are silicates? Why are so many of them silicates?

……
……
……
……
……
……
……

4. Make a table with two columns. In the left column, list the basic silicate structures. In the right column, list one or more rock-forming minerals with each structure.

……
……
……
……
……
……
……

6.7. Note the following technical words and their definitions and translate the words into Persian.

Technical words	Definitions
Crystal (noun)	a homogeneous, solid body of a compound
Crystallize (verb)	form into crystals
Crystalline (adjective)	made of crystal
Crystallization (noun)	forming into crystals
Crystallography (noun)	study of crystals
Crystallographic (adjective)	of the study of crystals

Now, fill in the blanks with the appropriate words.

1. Minerals have a ..... structure.
2. Geologists commonly use physical properties such as ..... habit, cleavage, and hardness to identify minerals.
3. Chemical composition and ..... structure are the two most important properties of a mineral.
4. Some minerals cleave along the plane of ..... weakness.
5. In addition to the chemical analysis, a complete description of a mineral requires knowledge of its .....
6. Intrusive rocks formed by ..... of the magma in the magma chamber.
7. The ..... form is best developed when the mineral can ..... slowly from the fluid that contains its elements.

6.8. Fill in the blanks with the following words and translate the passage into Persian.

"translucent", "color", "crystal habits", "hardness", "crystal system", "conchoidal", "colorless", "dispersion", and "waxy".

Physical Characteristics of Diamond

- ……**1**……. is variable and tends toward pale yellows, browns, grays, and also white, blue, black, reddish, greenish and ……**2**…….

- Luster is adamantine to ……**3**……
- Transparency crystals are transparent to ……**4**……. in rough crystals.
- ……**5**……. is isometric.
- ……**6**……. include isometric forms such as cubes and octahedrons, twinning is also seen.
- Hardness is 10
- Specific gravity is 3.5 (above average)
- Cleavage is perfect in 4 directions forming octahedrons.
- Fracture is ……**7**…….
- Streak is white.
- Associated minerals are limited to those found in kimberlite rock, an ultramafic igneous rock composed mostly of olivine.
- Among other characteristics its refractive index is 2.4 (very high), ……**8**……. is 0.044 and it is fluorescent.
- Notable occurrences include South Africa and other localities throughout Africa, India, Brazil, Russia, Australia, and Arkansas.
- Best field indicator is extreme ……**9**…….

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

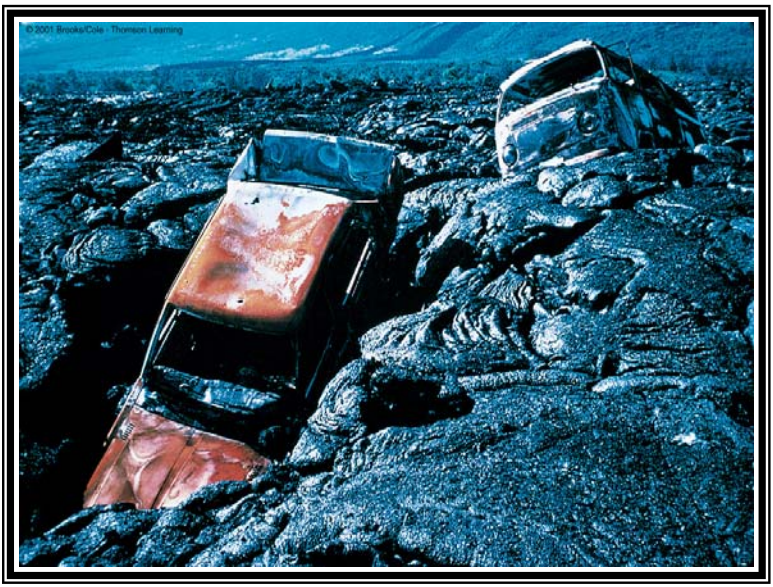
.....

6.9. Name the most common mineral groups (6 groups) and put the following minerals (Apatite, Dolomite, Galena, Gypsum, Magnetite, Quartz) into the table. Fill in other minerals.

Group						

UNIT 7

MAGMAS
AND
IGNEOUS ROCKS



هدف کلی

محتوای اصلی این درس که تحت عنوان Magmas and igneous rocks ارائه گردیده است، در خصوص آشنایی با ماگما، فرایندهای دخیل در تشکیل ماگما، مشخصات ماگما و انواع سنگ‌های آذرین می‌باشد. هدف کلی از تدوین این درس، آشنایی دانشجویان با تعدادی از واژه‌ها و اصطلاحات عمومی و واژه‌های کلیدی زمین‌شناسی و نیز کسب مهارت لازم در درک محتوای متن انگلیسی درس می‌باشد.

هدف‌های رفتاری

انتظار می‌رود دانشجو با مطالعه این فصل بتواند:

۱. معنی واژه‌های عام بخش ۷–۱ را با استفاده از فرهنگ لغات، مشخص نموده و مترادف و متضاد هر یک از واژه‌ها را بیاموزد.

۲. معنی واژه‌های کلیدی و تخصصی بخش ۷–۲ را پس از جستجو در فرهنگ لغات زمین‌شناسی، آموخته و تلفظ صحیح آنها را فرا گیرد.

۳. متن اصلی درس را با دقت مطالعه نموده و درک کلی از مفهوم ماگما، ترکیب و شرایط تشکیل انواع ماگماها و همچنین انواع سنگ‌های آذرین و بافت آنها داشته باشد.

۴. با توجه به مفهوم کلی درس، صحیح یا غلط‌بودن عبارات تمرین ۷–۴ را مشخص نماید.

۵. با توجه به متن درس، در بخش ۷–۵ مناسب‌ترین گزینه را از بین چهار گزینه، انتخاب و علامت‌گذاری نماید.

۶. پاسخ سؤالات بخش ۷–۶ را با توجه به مفهوم کلی درس، مشخص نموده و سعی نماید تا بدون استفاده از جمله‌بندی‌های متن درس، سؤالات را جواب دهد.

۷. اقسام کلام (اسم، فعل، قید و صفت) واژه تخصصی Magma به همراه تعاریف آنها را آموخته و قادر به به‌کار بردن این واژه‌ها در جملات مختلف تخصصی باشد.

۸. انواع سنگ‌های آذرین و تعاریف آنها را با یکدیگر جور نماید (بخش ۷–۸).

7.1. COMMON WORDS: Note the synonyms and antonyms of following words and translate the words into Persian.

Word	Synonym	Antonym
include	comprise	exclude
lowering	decreasing	increasing
within	inside	outside
expand	increase in size	contract
equal	identical	different
rare	uncommon, unusual	common

7.2. TECHNICAL WORDS: Note the pronunciation of the following technical words and expressions and translate them into Persian.

1. mantle plumes ……..
2. hot spot ……..
3. phenocryst /fen-ŏ-krist/ ……..
4. felsic /fel-sik/ ……..
5. mafic /maf-ik/ ……..
6. ultramafic /ul-tră-maf-sik/ ……..
7. intermediate ……..
8. basalt plateau /bă-sawlt, bass-awlt/ ……..
9. ferromagnesian minerals /fe-roh-magnee-shăn, -zhăn/ ……..
10. peridotite /pe-ră-dot-ÿt/ ……..
11. komatiite /kŏ-mat-ee-ÿt/ ……..
12. magmatic /mag-mat-ik/ ……..
13. lava ……..
14. hypabyssal /hÿ-pă-biss-ăl/ ……..
15. porphyritic texture /por-fă-rit-ik/ ……..
16. porphyry /por-fă-ree/ ……..
17. dunite /dew-nÿt/ ……..
18. orthopyroxene /or-th'oh-pÿ-roks-een/ ……..
19. harzburgite /harts-berg-ÿt/ ……..

7.3. Reading

MAGMAS AND IGNEOUS ROCKS

What is magma?

Magma is a hot silicate liquid beneath the Earth's surface (at depth between 100 to 350 kilometers) containing crystals and dissolved gases. **Igneous rocks** are formed from the crystallization and solidification of magma and are said to be **magmatic**. A **lava** represents magma extruded at the Earth's surface (**volcanic**) whereas magma solidifying at depth gives rise to **hypabyssal** and **plutonic** rocks.

Processes that form magma

Three different processes melt the asthenosphere (Fig. 7-1):

a) rising temperature
b) lowering of pressure
c) addition of water

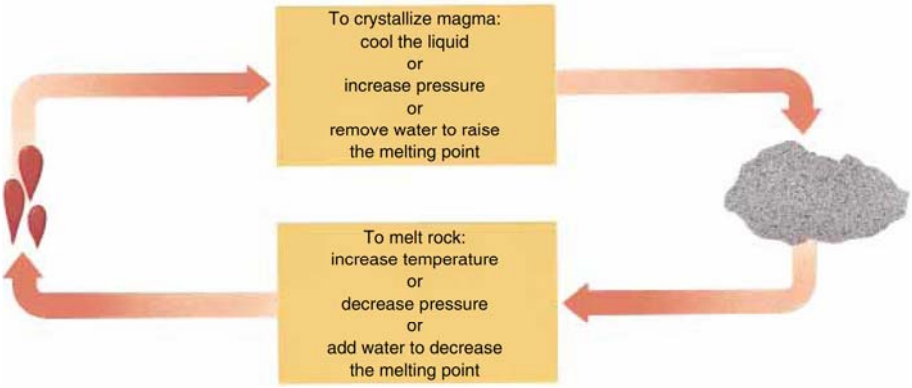


Figure 7-1. The lower box shows that increasing temperature, addition of water, and decreasing pressure all melt rock to form magma. The upper box shows that cooling, increasing pressure, and water loss all solidify magma to form an igneous rock.

These processes form great quantities of magma in three geologic environments: spreading centers, **mantle plumes**, and subduction zones.

A mantle plume is a rising column of hot, plastic mantle rock that originates deep within the mantle. The plume rises because it is hotter than the surrounding mantle and, consequently, is buoyant. As a

mantle plume rises, pressure-release results in a melted form of magma which erupts onto the Earth's surface. A **hot spot** is a volcanically active place at the Earth's surface directly above a mantle plume. Because mantle plumes form below the asthenosphere, hot spots can occur within a tectonic plate (Fig.7-2).

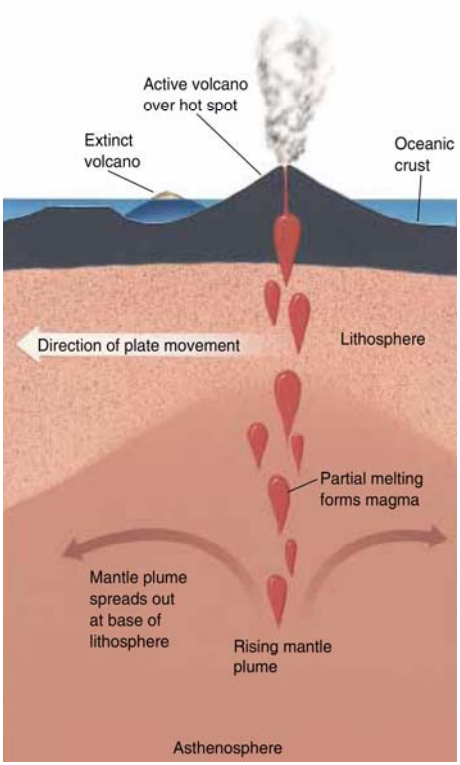


Figure 7-2. Pressure-release melting occurs where hot asthenosphere rises beneath a spreading center.

Characteristics of magma

All magmas are nearly silicate type, because oxygen and silicon are the two most abundant elements in the crust and mantle. In addition to oxygen and silicon, they also contain lesser amounts of the six other common elements of the Earth's crust: aluminum, iron, magnesium, calcium, potassium, and sodium.

The main variations among different types of magmas are differences in the relative proportions of these eight elements. For example, basaltic

magma contains more iron and magnesium than granitic magma, but granitic magma is richer in silicon, potassium, and sodium.

The temperature of magma varies from about 600˚C to 1400˚C Magma usually rises toward the Earth's surface because it is of lower density than rocks that surround it. When a silicate rock melts, the resulting magma expands by about 10 percent. It is then of lower density than the rock around it, so magma rises as it forms.

Textures of igneous rocks

The texture of a rock refers to the size, shape, and arrangement of its mineral grains, or crystals. Volcanic rocks are usually **fine grained**, whereas plutonic rocks are **medium** or **coarse grained**.

If magma rises slowly through the crust before erupting, some crystals may grow while most of the magma remains molten. If this mixture of magma and crystals then erupts onto the surface, it solidifies quickly, forming **porphyry**. In a **porphyritic texture**, the large crystals, called **phenocrysts**, embedded in a fine-grained matrix.

Naming igneous rocks

Geologists use both the minerals and texture to classify and name igneous rocks. For example, any medium- or coarse-grained igneous rock consisting mostly of feldspar and quartz is called **granite**. **Rhyolite** also consists mostly of feldspar and quartz but is very fine grained.

Granite and rhyolite contain large amounts of feldspar and silica, and so are called **felsic** rocks. **Basalt** and **gabbro** are called **mafic** rocks because of their high magnesium and iron contents.

Rocks with especially high magnesium and iron concentrations are called **ultramafic**. Rocks with compositions between those of granite and basalt are called **intermediate** rocks.

Common igneous rocks

Granite and Rhyolite

Granite is a felsic rock that contains mostly feldspar and quartz. Small

amounts of dark biotite or hornblende often give it a black and white dotted appearance. Granites (and metamorphosed granitic rocks) are the most common rocks in continental crust.

As granitic magma rises through the Earth's crust, some of it may erupt from a volcano to form rhyolite, while the remainder solidifies beneath the volcano, forming granite. Most **obsidian** forms from magma with a granitic (rhyolitic) composition.

Basalt and Gabbro

Basalt is a mafic rock that consists of approximately equal amounts of plagioclase feldspar and pyroxene. It makes up most of the oceanic crust as well as huge **basalt plateaus** on continents.

Gabbro is the plutonic equivalent of basalt; it is mineralogically identical but consists of larger crystals. Gabbro is uncommon at the Earth's surface.

Andesite and Diorite

Andesite is a volcanic rock intermediate in composition between basalt and granite. It is commonly gray or green and consists of plagioclase and dark minerals (usually biotite, amphibole, or pyroxene).

Diorite is the plutonic equivalent of andesite. It forms from the same magma as andesite.

Peridotites

Peridotites are **ultramafic** igneous rocks that make up most of the upper mantle but are rare in the Earth's crust. They are coarse grained and composed of olivine, and usually contain pyroxene, amphibole, or mica but no feldspar. For instance, **dunite** is a monomineralic ultramafic rock consisting wholly of olivine, but **harzburgite** consisting largely of olivine and orthopyroxene.

A **komatiite** is a typical ultramafic extrusive rock that is mostly olivine and pyroxene, with lesser feldspar.

EXERCISES

7.4. According to the passage, which of the following statements are "true" or "false"? Insert "T" or "F" in the boxes at the right.

1. Granite is a mafic rock that contains mostly feldspar and quartz.
2. When a silicate rock melts, it is then of lower density.
3. Harzburgite is a monomineralic ultramafic rock.
4. Obsidian forms from magma with a basaltic composition.
5. Rising of pressure melts portions of the Earth's asthenosphere.
6. Intrusive rocks crystallized from magmas that did not reach the surface.

7.5. Choose a, b, c, or d which best completes each item.

1. Which of the following rocks is felsic?
   a) Gabbro b) Basalt
   c) Peridotite d) Obsidian
2. What is the volcanic equivalent of Diorite?
   a) Basalt b) Andesite
   c) Obsidian d) Rhyolite
3. …….. consists mostly of feldspar and quartz but is very fine grained.
   a) Rhyolite b) Granite
   c) Basalt d) Andesite
4. Which of the following rocks are uncommon in the Earth's crust?
   a) Peridotites b) Granites
   c) Rhyolites d) Diorites

5. Basalt plateaus are found on ……..
   a) continents b) oceans
   c) lithosphere d) oceanic crust

7.6. Write the answers to the following questions in your own words.

1. What is the temperature of magma?

……
……
……
……
……
……
……

2. What is the general chemical composition of most magmas?

……
……
……
……
……
……
……

3. Why do magmas begin to rise through the Earth's outer layers as soon as they form?

……
……
……
……
……
……
……

4. How would you distinguish a plutonic rock from a volcanic rock in

the field?

……
……
……
……
……
……
……

5. What factor distinguishes obsidian from all other types of igneous rocks?

……
……
……
……
……
……
……

6. What are the most common minerals in igneous rocks? Why?

……
……
……
……
……
……
……

7. What do the terms *mafic*, *ultramafic*, *felsic*, and *intermediate* mean?

……
……
……
……
……
……
……

8. Describe the mineralogy, texture, and common geologic occurrence

of the following types of igneous rocks: granite, rhyolite, basalt, gabbro, andesite, and peridotite.

……
……
……
……
……
……
……

9. What type of igneous rock is the most abundant constituent of continental crust? What type makes up most oceanic crust?

……
……
……
……
……
……
……

7.7. Note the following technical words and their definitions and translate the words into Persian.

Technical words	Definitions
Magma (noun)	Molten rock beneath the earth's crust from which igneous rocks are formed.
Magmatism	The development and movement of magma, and it's solidification to igneous rocks.
Magmatic (adjective)	Related to or derived from magma.
Magmatically (adverb)	

Now, fill in the blanks with the appropriate words.

1. Andean ..... is well developed in two regions.

2. In south-eastern Australia, the ..... forms flows and shallow intrusions.
3. In Australia, major ..... activity occurred in the Cambrian- Ordovician.
4. When the kimberlite reaches the surface, the sudden release of ..... gas and interaction with groundwater causes explosions.
5. The molten rock cools in ..... chambers.
6. Abundant ..... occurred during Devonian period of the Paleozoic era.
7. Beneath continental crust, large igneous bodies may be considered as a ..... underplated layer.

7.8. Match the different types of igneous rocks to their definitions.

Rock type	Definition
1. Rhyolite	A) A mafic rock and has the same chemistry and mineralogy as basalt.
2. Granite	B) A group of rocks completely composed of ferromagnesian minerals, mostly olivine and pyroxene.
3. Ultramafic	C) Rock which contain no feldspar.
4. Peridotite	D) A medium- or coarse-grained igneous rock consisting mostly of feldspar and quartz.
5. Basalt	E) The most common extrusive rock in oceanic crust.
6. Komatiite	F) A plutonic rock intermediate in composition between basalt and granite and consists of plagioclase and ferromagnesian minerals.
7. Diorite	G) A volcanic glass with granitic composition.
8. Gabbro	H) An extrusive felsic rock.
9. Obsidian	I) Volcanic equivalent of peridotite

1—— 2—— 3—— 4—— 5—— 6—— 7——
8—— 9——

UNIT 8

SEDIMENTARY ROCKS AND STRUCTURES

هدف کلی

محتوای اصلی این درس که تحت عنوان Sedimentary rocks and structures ارائه گردیده است، در خصوص آشنایی با نحوه تشکیل سنگ‌های رسوبی، انواع آنها و ساختمان‌های موجود در سنگ‌های رسوبی می‌باشد. هدف کلی از تدوین این درس، آشنایی دانشجویان با تعدادی از واژه‌ها و اصطلاحات عمومی و واژه‌های کلیدی زمین‌شناسی و نیز کسب مهارت لازم در درک محتوای متن انگلیسی درس می‌باشد.

هدف‌های رفتاری

انتظار می‌رود دانشجو با مطالعه این فصل بتواند:

۱. معنی واژه‌های عام بخش ۸–۱ را با استفاده از فرهنگ لغات، مشخص نموده و مترادف و متضاد هر یک از واژه‌ها را بیاموزد.

۲. معنی واژه‌های کلیدی و تخصصی بخش ۸–۲ را پس از جستجو در فرهنگ لغات زمین‌شناسی، آموخته و تلفظ صحیح آنها را فرا گیرد.

۳. متن اصلی درس را با دقت مطالعه نموده و درک کلی از مفهوم رسوب، فرایندهای رسوبگذاری، انواع سنگ‌های رسوبی و ساختمان‌های موجود در آنها داشته باشد.

۴. با توجه به مفهوم کلی درس، صحیح یا غلطبودن عبارات تمرین ۸–۴ را مشخص نماید.

۵. با توجه به متن درس، در بخش ۸–۵ مناسب‌ترین گزینه را از بین چهار گزینه، انتخاب و علامت‌گذاری نماید.

۶. پاسخ سؤالات بخش ۸–۶ را با توجه به مفهوم کلی درس، مشخص نموده و سعی نماید تا بدون استفاده از جمله‌بندی‌های متن درس، سؤالات را جواب دهد.

۷. اقسام کلام (اسم، فعل، قید و صفت) واژه تخصصی Deposit به همراه تعاریف آنها را آموخته و قادر به به‌کار بردن این واژه‌ها در جملات مختلف تخصصی باشد.

۸. متن انگلیسی بخش ۸–۸ را به فارسی روان ترجمه نموده و سپس با درک کلی از مفهوم متن مذکور، انواع محیط‌های رسوبی نمایش داده‌شده در شکل ۸–۲ را با تعاریف آنها جور نماید.

8.1. COMMON WORDS: Note the synonyms and antonyms of following words and translate the words into Persian.

Word	Synonym	Antonym
angular	having angles	rounded
obvious	clear	imperceptible
accumulate	be collected	disperse
shrink	instance of contracting	expand
shallow	having little depth	deep

8.2. TECHNICAL WORDS: Note the pronunciation of the following technical words and expressions and translate them into Persian.

1. clastic sedimentary rocks /klass-tik/ ……..
2. bio-chemical sedimentary rocks ……..
3. pyroclastic sedimentary rocks /pÿ-rŏ-klass-tik/ ……..
4. deposit ……..
5. clast ……..
6. conglomerates ……..
7. siltstone ……..
8. breccias /brech-ee-ă, bresh-/ ……..
9. claystone ……..
10. mudstone ……..
11. gravel ……..
12. rubble ……..
13. mud ……..
14. rock salt ……..
15. chert ……..
16. coal ……..
17. sedimentary structures ……..
18. bedding ……..
19. stratification /strat-ă-fă-kay-shŏn/ ……..

20. cross-bedding ……..
21. ripple marks ……..
22. mud cracks ……..
23. graded bedding ……..
24. flood plain ……..
25. submarine canyon ……..
26. lagoon ……..
27. reef ……..
28. sand dune ……..
29. delta ……..
30. continental shelf ……..
31. continental slope ……..
32. continental rise ……..

8.3. Reading

SEDIMENTARY ROCKS AND STRUCTURES

The origin of sedimentary rocks

Weathering decomposes bedrocks. Flowing water, wind, gravity, and glaciers then erode the decomposed rocks, transport them downslopes and finally deposit them on the sea coast. Finally, the loose sediment is cemented to form hard sedimentary rock. Sedimentary rocks make up only about 5 percent of the Earth's crust, but cover about 75 percent of the surface of the continents.

Types of sedimentary rocks

Sedimentary rocks are divided into three main classes:

1. **Clastic sedimentary rocks:** Clastic sedimentary rocks are composed of fragments of weathered rocks, called **clasts**. These are grains that have been transported, deposited, and cemented together. Clastic rocks includes conglomerates, sandstones, siltstones and **shales** and make up more than 85 percent of all sedimentary rocks

(Fig. 8–1). **Conglomerate** and **breccia** are coarse-grained clastic rocks. **Sandstone** is a clastic sedimentary rock comprising mainly sand-sized grains. **Claystone**, shale, **mudstone**, and **siltstone** are all fine grained clastic rocks.

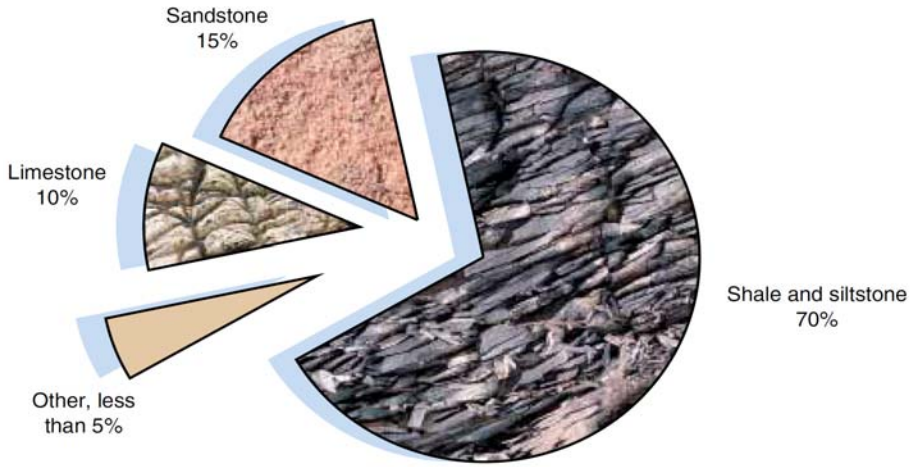


Figure 8-1. Relative abundances of sedimentary rock types.

Clastic sediment is named according to particle size (Table 8–1). **Gravel** includes all rounded particles larger than 2 millimeters in diameter. Angular particles in the same size range are called **rubble**. **Sand** ranges from 1/16 to 2 millimeters in diameter. **Silt** varies from 1/256 to 1/16 millimeter. **Clay** is less than 1/256 millimeter in diameter. **Mud** is wet silt and clay.

Table 8-1. Sizes and names of sedimentary particles and clastic rocks.

DIAMETER(mm)	*SEDIMENT*		*CLASTIC SEDIMENTARY ROCKS*
>2	Boulders Cobbles Pebbles	Gravel (rubble)	Conglomerate (rounded particles)
1/16-2	Sand		Sandstone
1/256-1/16	Silt	Mud	Siltstone Mudstone
<1/256	Clay		Claystone or Shale

2. **Bio-chemical sedimentary rocks:** Bio-chemical sedimentary rocks consist of the remains of plants or animals or form by direct

precipitation of minerals from solution. **Limestone** containing fossils, for example, is a bio-chemical sedimentary rock formed in ancient seas.

Rock salt is an example of chemical sedimentary rock forms when salt precipitates from evaporating seawater or saline lake water. Organic sedimentary rocks, such as **chert** and **coal**, form by lithification of the remains of plants and animals.

3. **Pyroclastic sedimentary rocks:** Pyroclastic sedimentary rocks are a type of sedimentary rocks composed primarily of volcanic materials that has been transported and reworked through mechanical action, such as by wind or water. In other words we can define pyroclastic rocks as they are formed from lavas which are ejected into the air. They are also called volcaniclastic rocks. This group will be discussed in more details in unit 14.

Sedimentary structures

Nearly all sedimentary rocks contain **sedimentary structures**, features that developed during or shortly after deposition of the sediment. These structures help us understand how the sediment was transported and deposited.

The most obvious and common sedimentary structure is **bedding**, or **stratification** layering that develops as sediment is deposited. Bedding forms because sediment accumulates layer by layer. Nearly all sedimentary beds were originally horizontal.

Cross-bedding consists of small beds lying at an angle to the main sedimentary layering. Cross-bedding forms in many environments is where wind or water transports and deposits sediment.

Ripple marks are small, nearly parallel sand ridges and troughs that are also formed by moving water or wind. They are like dunes and sand waves, but smaller.

In **graded bedding**, the largest grains collect at the bottom of a layer and the grain size decreases toward the top.

Mud cracks are polygonal cracks that form when mud shrinks as

it dries. They indicate that the mud accumulated in shallow water that periodically dried up.

EXERCISES

8.4. According to the passage, which of the following statements are "true" or "false"? Insert "T" or "F" in the boxes at the right.

1. Chert is a clastic rock.
2. Cross-bedding is formed by wind or water action.
3. Chert is a rock composed of the remains of tiny marine organisms.
4. Mud is wet silt and gravel.
5. Breccia is a fine-grained clastic rock.
6. In a sedimentary breccia the particles are angular.

8.5. Choose a, b, c, or d which best completes each item.

1. Which of the following rocks are biochemical?
   a) Shale b) Breccia
   c) Limestone d) Siltstone
2. Which of the following structures are like dunes?
   a) Ripple marks b) Graded beddings
   c) Cross beddings d) Mud cracks
3. What is the composition of chert?
   a) Calcium carbonate b) Silica
   c) Plant remains d) Magnesium carbonates
4. Rubble is as the same size range as ……..

a) sand b) clay
c) mud d) gravel

5. Particle size in …….. varies from 1/256 to 1/16 millimeter.
a) gravel b) sand
c) clay d) silt

8.6. Write the answers to the following questions in your own words.

1. How do limestones form?

……
……
……
……
……
……
……

2. How do chert and coal form?

……
……
……
……
……
……
……

3. What is mud?

……
……
……
……
……
……
……

4. What does the presence of mud cracks in a mudstone tell you about the depositional environment?

……
……
……
……
……
……
……

5. What does cross-bedding in a sandstone tell you about depositional environment?

……
……
……
……
……
……
……

8.7. Note the following technical words and their definitions and translate the words into Persian.

Technical words	Definitions
Deposit (verb)	Consolidated or unconsolidated material that has accumulated by a natural process or agent.
Deposition (noun)	The laying down of material subsequent to erosion and transport.
Depositional (adjective)	pertaining to a deposition
Depositionally (adverb)	

Now, fill in the blanks with the appropriate words.

1. Studies of fossils and of the ..... order of sedimentary layers led to the principles of fossil succession.
2. The rivers carry and ..... sands and gravels in their beds.
3. Stratigraphers recognized cycles of weathering, erosion, transportation, ..., and diagenesis.
4. The ..... of sediments in the oceans would presumably raise sea-level enough to flood much of the land surface.
5. In some places in central Iran, metavolcanic rocks, lies ..... on sedimentary formations.
6. Several ..... environments have been suggested for the formations in Zagros.
7. The hard, laminated interior of the stromatolite records the ..... history of the stromatolite building process.

8.8. Read the following passage and translate into Persian. Then, match some of the different types of depositional environments to their definitions according to figure 8-2.

Interpreting sedimentary rocks:
Depositional environments

Geologists study sedimentary rocks to help us understand the past. When geologists study sedimentary rocks, they ask questions such as: Where did the sediment originate? Was the sediment transported by a stream, wind, or a glacier? In what environment did the sediment accumulate? If it was deposited in the sea, was it on a beach or in deep water? If it was deposited on land, was it in a lake, a stream bed, or a flood plain?

Geologists answer these questions by analyzing the minerals, textures, and structures of sedimentary rocks. Additionally, the size and shape of a sedimentary rock layer contain clues to its depositional environment.

Accurate interpretations of depositional environments are often profitable, because valuable concentrations of oil and gas, coal, evaporites, and metals form in certain types of environments.

Depositional environments vary greatly in scale, from an entire ocean basin to a 3-meter-long sand bar in a stream. Many small-scale environments may be active within a single large-scale depositional system (Fig. 8–2).

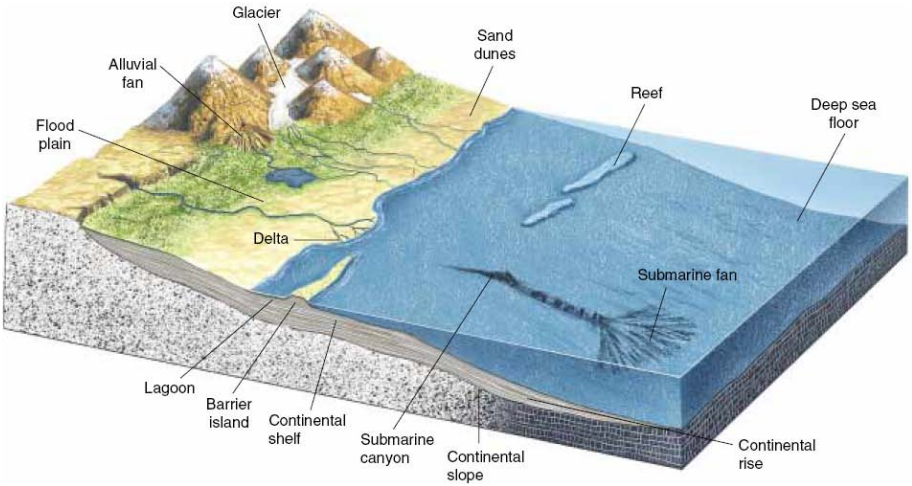


Figure 8–2. Common depositional environments.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

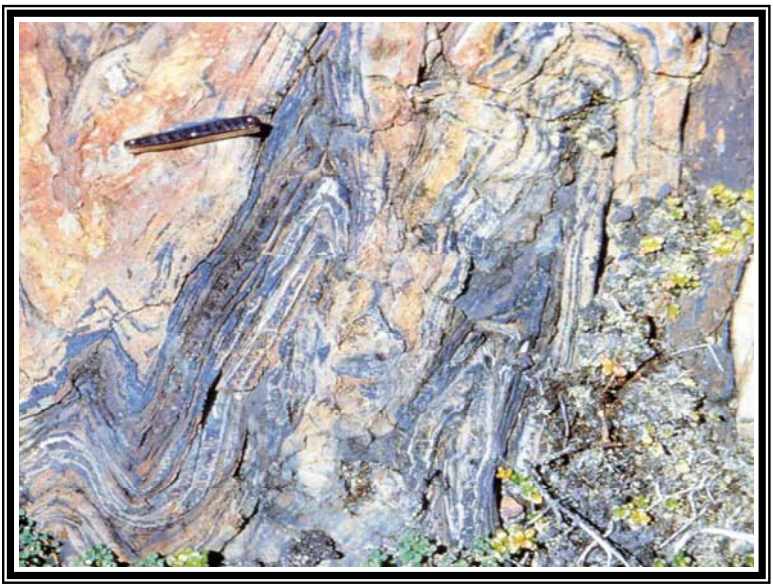
.....

Depositional environment	**Definition**
1. Glacier	A) ridge of coral or rock located near the surface of the sea
2. Flood plain	B) triangular section of land at the mouth of a river
3. Submarine canyon	C) very large mass of ice formed through the gradual accumulation of snow in high cold regions
4. Lagoon	D) flat low-lying ground alongside a river that is flooded when the river overflows its banks
5. Reef	E) shallow body of water which is cut of from the sea by sand dunes
6. Sand dune	F) Valleys of the deep sea floor
7. Delta	G) small hill made of sand

1—— 2—— 3—— 4—— 5—— 6—— 7——

UNIT 9

METAMORPHISM AND METAMORPHIC ROCKS



هدف کلی

محتوای اصلی این درس که تحت عنوان Metamorphism and metamorphic rocks ارائه گردیده است، در خصوص آشنایی با فرایند دگرگونی و انواع سنگ‌ها و رخساره‌های دگرگونی می‌باشد. هدف کلی از تدوین این درس، آشنایی دانشجویان با تعدادی از واژه‌ها و اصطلاحات عمومی و واژه‌های کلیدی زمین‌شناسی و نیز کسب مهارت لازم در درک محتوای متن انگلیسی درس می‌باشد.

هدف‌های رفتاری

انتظار می‌رود دانشجو با مطالعه این فصل بتواند:

۱. معنی واژه‌های عام بخش ۹–۱ را با استفاده از فرهنگ لغات، مشخص نموده و مترادف و متضاد هر یک از واژه‌ها را بیاموزد.
۲. معنی واژه‌های کلیدی و تخصصی بخش ۹–۲ را پس از جستجو در فرهنگ لغات زمین‌شناسی، آموخته و تلفظ صحیح آنها را فرا گیرد.
۳. متن اصلی درس را با دقت مطالعه نموده و درک کلی از مفهوم دگرگونی، عوامل دخیل در دگرگونی، انواع دگرگونی و سنگ‌های مربوطه و انواع رخساره‌های دگرگونی و شرایط تشکیل آنها داشته باشد.
۴. با توجه به مفهوم کلی درس، صحیح یا غلط‌بودن عبارات تمرین ۹–۴ را مشخص نماید.
۵. با توجه به متن درس، در بخش ۹–۵ مناسب‌ترین گزینه را از بین چهار گزینه، انتخاب و علامت‌گذاری نماید.
۶. پاسخ سؤالات بخش ۹–۶ را با توجه به مفهوم کلی درس، مشخص نموده و سعی نماید تا بدون استفاده از جمله‌بندی‌های متن درس، سؤالات را جواب دهد.
۷. اقسام کلام (اسم، فعل، قید و صفت) واژه تخصصی Metamorphism به همراه تعاریف آنها را آموخته و قادر به به‌کار بردن این واژه‌ها در جملات مختلف تخصصی باشد.
۸. متن انگلیسی بخش ۹–۸ را با واژه‌های داده شده تکمیل و سپس آن را به فارسی روان ترجمه نماید.
۹. انواع سنگ‌های دگرگونی و تعاریف آنها را با یکدیگر جور نماید (بخش ۹–۹).

9.1. COMMON WORDS: Note the synonyms and antonyms of following words and translate the words into Persian.

Word	Synonym	Antonym
widespread	extensive	limited
broad	wide	narrow
abundant	plentiful	scarce
associate	connected	unrelated
perpendicular	vertical	horizontal
active	constantly moving	passive

9.2. TECHNICAL WORDS: Note the pronunciation of the following technical words and expressions and translate them into Persian.

1. metamorphism /met-ă-mor-fiz-ăm/ ……..
2. parent rock ……..
3. protolith ……..
4. deformation /dee-for-may-shŏn/ ……..
5. foliation ……..
6. metamorphic /metă-mor-fik/ ……..
7. grade ……..
8. geothermal gradient /jee-oh-th'er-măl/ ……..
9. contact metamorphism ……..
10. country rock ……..
11. metamorphic halo ……..
12. hornfels /horn-fels/ ……..
13. burial metamorphism ……..
14. sedimentary basin ……..
15. argillite /ar-jă-lÿt/ ……..
16. quartzite /kwort-sÿt/ ……..
17. marble ……..
18. regional metamorphism ……..
19. slate ……..

20. phyllite /fil-ÿt/ ……..
21. schist /shist/ ……..
22. gneiss /nÿss/ ……..
23. migmatite /mig-mă-tÿt/ ……..
24. metamorphic facies ……..
25. zeolite /zee-ŏ-lÿt/ ……..
26. prehnite /pray-nÿt, pren-ÿt/ ……..
27. pumpellyite /pum-pel-ee-ÿt/ ……..
28. greenschist /green-shist/ ……..
29. blueschist ……..
30. granulite /gran-yŭ-lÿt/ ……..
31. amphibolite /am-fib-ŏ-lÿt/ ……..

9.3. Reading

METAMORPHISM AND METAMORPHIC ROCKS

The origin of metamorphic rocks

When rocks are subjected to deep burial, tectonic forces such as folding, and high pressures and temperatures, the textures and mineral compositions begin to change. This process called **metamorphism.**

Metamorphism is the solid-state transformation (no melting) of a rock mass into a rock of generally the same chemistry but with different textures and minerals. Usually the **metamorphic rock** is different from the original rock, called the **parent rock** or **protolith**.

Factors Controlling Metamorphism

Most metamorphic reactions occur because each mineral is stable only within a certain range of temperature, pressure, and chemical environment. If temperature or pressure rises above that range, or if the chemical environment changes, a new mineral forms. **Deformation** creates a banded structure called **foliation**.

Both the texture and the minerals can change as a rock is

metamorphosed. The mineralogy of a metamorphic rock reflects its **metamorphic grade**. Metamorphic grade is the temperature and pressure at which it formed. The increase in the Earth's temperature with depth from its surface is called the **geothermal gradient**. Consequently, the metamorphic grade of many rocks is related to the depth. Metamorphic grade is often expressed by the relative terms **low-**, **medium-**, and **high-grade metamorphism** (Fig. 9-1).

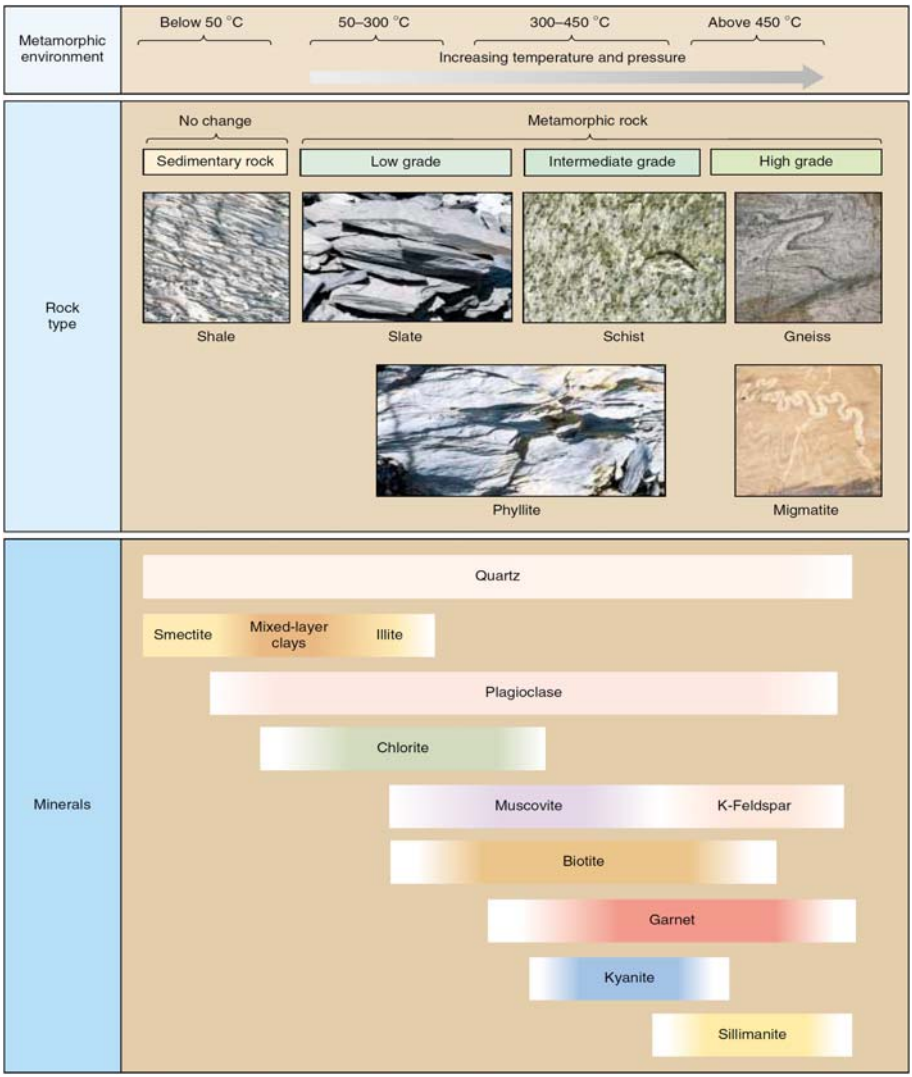


Figure 9-1. Shale changes in both texture and minerals as metamorphic grade increases. The lower part of the figure shows the stability ranges of common metamorphic minerals.

Types of metamorphism and metamorphic rocks

1. **Contact metamorphism: Contact metamorphism** occurs where hot magma intrudes cooler **country rock**. The country rock may be of any type sedimentary, metamorphic, or igneous. A **metamorphic halo** around a pluton can range in width from less than a meter to hundreds of meters. Contact metamorphism commonly occurs without deformation.

   The **hornfels** is a hard, dark, fine grained rock usually formed by contact metamorphism of shale.
2. **Burial metamorphism: Burial metamorphism** results from deep burial of rocks in a **sedimentary basin**. Burial metamorphism occurs without tectonic deformation. Because of the lack of deformation, rocks formed by burial metamorphism often retain sedimentary structures.

   Shale and siltstone become harder and better lithified to form **argillite.** Quartz sandstone becomes **quartzite**. Burial metamorphism converts limestone and dolomite to **marble**.
3. **Regional metamorphism: Regional metamorphism** occurs in and near a subduction zone. It is the most common type of metamorphism. Regionally metamorphosed rocks are strongly foliated and are associated with mountains and igneous rocks. Shale consists of clay minerals, quartz, and feldspar and is the most abundant sedimentary rock. As regional metamorphism begins, the clay minerals break down and are replaced by mica and chlorite. These new, platy minerals grow perpendicular to the direction of tectonic forces. As a result, the rock develops **slaty cleavage** and is called **slate** (Fig. 9-1)**.**

   With rising temperature and continued deformation, the micas and chlorite grow larger, and form a rock called **phyllite** (Fig. 9-1).

   As temperature continues to rise, the mica and chlorite grow large enough to be seen by the naked eye, and foliation becomes very well developed. Rock of this type is called **schist** (Fig. 9-1)**.**

   At high metamorphic grades, light- and dark-colored minerals often

separate into bands that are thicker than the layers of schist to form a rock called **gneiss** (pronounced “nice”) (Fig. 9-1).

At the highest metamorphic grade, the rock begins to melt, forming small veins of granitic magma. When metamorphism decrease and the rock cools, the magma veins solidify to form **migmatite**, a mixture of igneous and metamorphic rock (Fig. 9-1).

Metamorphic facies

All metamorphic rocks that formed under identical temperature and pressure are grouped into a **metamorphic facies**. Metamorphic facies differ from one another, because they form under different conditions of temperature and pressure.

Each facies is given a name derived from a mineral and/or texture commonly found in rocks of that facies (Fig. 9-2).

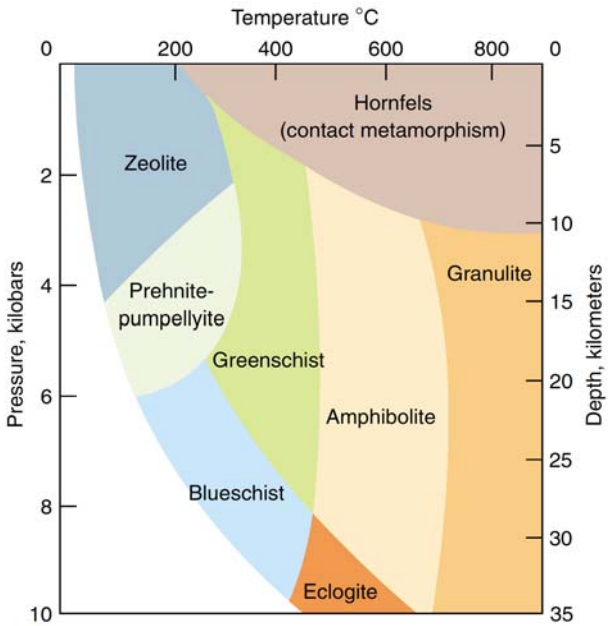


Figure 9-2. The names and metamorphic conditions of the metamorphic facies.

In general, from low grade (lower pressure and temperature) to high grade (higher pressure and temperature), the following facies are recognized:

Zeolite: low temperature, low pressure
Prehnite-pumpellyite: low temperature, low-medium pressure
Greenschist: low-medium temperature, low-medium pressure
Blueschist: low-medium temperature, high pressure
Amphibolite: medium-high temperature, medium-high pressure
Granulite: high temperature, high pressure

EXERCISES

9.4. According to the passage, which of the following statements are "true" or "false"? Insert "T" or "F" in the boxes at the right.

1. Slate is an intermediate grade metamorphic rock.
2. Migmatite is a mixture of sedimentary and metamorphic rock.
3. With the beginning of the regional metamorphism, the clay minerals are replaced by mica and chlorite.
4. Slate is a contact metamorphic rock.
5. Gneiss is formed from migmatite.
6. Foliation is formed by deformation.
7. Marble is a burial metamorphic rock.

9.5. Choose a, b, c, or d which best completes each item.

1. Which of the following rocks are the most abundant sedimentary rocks?
   a) slate b) shale

c) argillite d) limestone

2. With rising temperature and continued deformation, schist change in to ……..
   a) phyllite b) slate
   c) gneiss d) migmatite
3. Which of the following types of metamorphism occur in or near mountain building regions?
   a) dynamothermal metamorphism b) burial metamorphism
   c) contact metamorphism d) low grade metamorphism
4. The rate at which temperature increases with depth is called the ……..
   a) metamorphic facies b) geothermal gradient
   c) metamorphic grade d) protolith
5. Burial metamorphism changes the shale and siltstone in to ……..
   a) schist b) slate
   c) argillite d) gneiss

9.6. Write the answers to the following questions in your own words.

1. Describe the two general kinds of changes that a rock undergoes during metamorphism.

…….
……
……..……
……..……
……..…
……..…
……..…

2. Name and briefly describe each of the different types of metamorphism.

…….
……

……
……
……
……
……

3. Describe and name a rock that might result from contact metamorphism of a shale.

……
……
……
……
……
……
……

4. What rock types might form by contact metamorphism of limestone?

……
……
……
……
……
……
……

5. Describe and name the succession of metamorphic rocks that form as shale experiences progressively higher grades of regional metamorphism.

……
……
……
……
……
……
……

6. What is a metamorphic facies?

……

……
……
……
……
……
……

9.7. Note the following technical words and their definitions and translate the words into Persian.

Technical words	Definitions
Metamorphism (noun)	Metamorphism is the process by which solid rocks and minerals change in response to changing environmental conditions.
Metamorphic (adjective)	Relate to metamorphism
Metamorphically (adverb)	
Metamorphite (noun)	metamorphic rock
Metamorphose (verb)	

Now, fill in the blanks with the appropriate words.

1. A ..... rock forms when any preexisting rock is altered by heating, increased pressure, or tectonic deformation.
2. About 95 percent of the Earth's crust consists of igneous rock and ..... igneous rock.
3. Parent rock is any original rock before it is changed by ..... or any other geologic process.
4. Regionally ..... rocks are strongly foliated and are typically associated with mountains and igneous rocks.
5. Regional ..... produces zones of foliated ..... rock tens to hundreds of kilometers across.
6. When a rock is buried, its temperature and pressure increase, causing changes in both minerals and the texture of the rock. These

changes are called ....., and the rock formed by these processes is a .....

7. Gneiss is a highly deformed and ..... recrystallized rock.

9.8. Fill in the blanks with the following words and translate the passage into Persian.

"metamorphism", "deform", "collision", "pressures", "faulting", "forces", "magmas".

Metamorphism and Plate Tectonics

Metamorphic rocks result from the ……**1**……. active during plate tectonic processes. The ……**2**……. of plates, subduction, and the sliding of plates along transform faults create differential stress, friction, shearing, compressive stress, folding, ……**3**……., and increased heat flow.

The tectonic forces ……**4**……. and break the rock, creating openings, cracks, faults, breccias, and zones of weakness along which ……**5**……. can rise .Generally, the greater the tectonic forces, the higher the ……**6**……. and temperatures affecting a rock mass and the greater the amount of resulting structural deformation and ……**7**…….

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

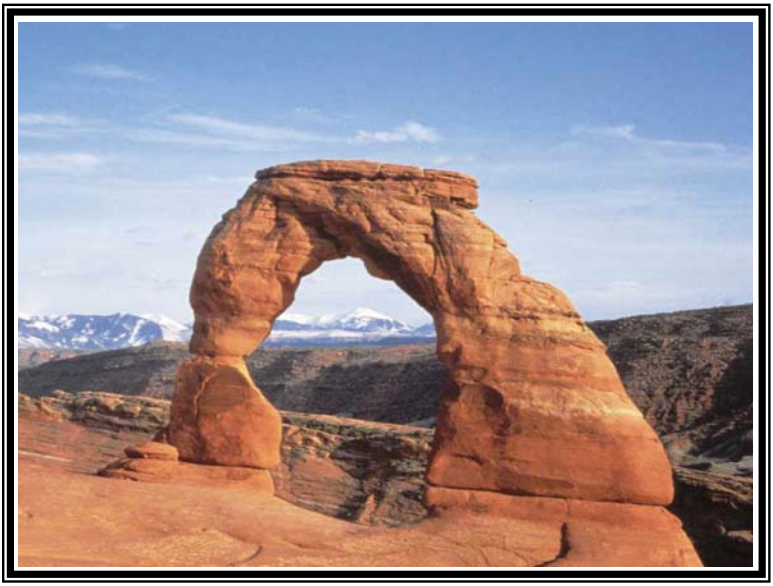
9.9. Match the different types of metamorphic rocks to their definitions.

Metamorphic rock	Definition
1. Phyllite	A) form when temperatures are hot enough to partially melt the rock.
2. Schist	B) is a metamorphosed limestone.
3. Quartz sandstone	C) is slightly more metamorphosed than slate and contain mica crystals and a silky appearance.
4. Slate	D) is coarser grained than phyllite or slate and has aligned minerals that can be identified with the naked eye.
5. marble	E) is generally fine-grained, dark-colored, metamorphosed sedimentary rocks that split easily along slaty foliations and was formed under low-grade temperature and pressure conditions.
6. Migmatite	F) is the protolith of quartzite.F
7. Transport	G) Water below the surface and its location in different soil layers and gaps.

1—— 2—— 3—— 4—— 5—— 6—— 7——

UNIT 10

WEATHERING, EROSION AND SOIL



هدف کلی

محتوای اصلی این درس که تحت عنوان Weathering, erosion and soil ارائه گردیده است، در خصوص آشنایی با فرایندهای هوازدگی، فرسایش و نحوه تشکیل انواع خاک‌ها می‌باشد. هدف کلی از تدوین این درس، آشنایی دانشجویان با تعدادی از واژه‌ها و اصطلاحات عمومی و واژه‌های کلیدی زمین‌شناسی و نیز کسب مهارت لازم در درک محتوای متن انگلیسی درس می‌باشد.

هدف‌های رفتاری

انتظار می‌رود دانشجو با مطالعه این فصل بتواند:

۱. معنی واژه‌های عام بخش ۱۰–۱ را با استفاده از فرهنگ لغات، مشخص نموده و مترادف و متضاد هر یک از واژه‌ها را بیاموزد.
۲. معنی واژه‌های کلیدی و تخصصی بخش ۱۰–۲ را پس از جستجو در فرهنگ لغات زمین‌شناسی، آموخته و تلفظ صحیح آنها را فرا گیرد.
۳. متن اصلی درس را با دقت مطالعه نموده و درک کلی از مفهوم هوازدگی و فرایندهای کنترل‌کننده آن، و نیز تشکیل انواع خاک داشته باشد.
۴. با توجه به مفهوم کلی درس، صحیح یا غلط‌بودن عبارات تمرین ۱۰–۴ را مشخص نماید.
۵. با توجه به متن درس، در بخش ۱۰–۵ مناسب‌ترین گزینه را از بین چهار گزینه، انتخاب و علامت‌گذاری نماید.
۶. پاسخ سؤالات بخش ۱۰–۶ را با توجه به مفهوم کلی درس، مشخص نموده و سعی نماید تا بدون استفاده از جمله‌بندی‌های متن درس، سؤالات را جواب دهد.
۷. اقسام کلام (اسم، فعل، قید و صفت) واژه تخصصی erosion به همراه تعاریف آنها را آموخته و قادر به به‌کار بردن این واژه‌ها در جملات مختلف تخصصی باشد.
۸. متن انگلیسی بخش ۱۰–۸ را با واژه‌های داده‌شده تکمیل و آن را به فارسی روان ترجمه نماید.

10.1. COMMON WORDS: Note the synonyms and antonyms of following words and translate the words into Persian.

Word	Synonym	Antonym
freezing	very cold, icy	hot, balmy
major	significant	minor
release	liberation	imprison
push	apply pressure	pull
fertile	fruitful	barren
rapid	quick, fast	slow

10.2. TECHNICAL WORDS: Note the pronunciation of the following technical words and expressions and translate them into Persian.

1. weathering ……..
2. erosion ……..
3. transport ……..
4. deposit ……..
5. sedimentary deposits ……..
6. erode ……..
7. transform ……..
8. mechanical weathering ……..
9. external conditions ……..
10. pressure-release fracturing ……..
11. tectonic uplift /tek-tonn-ik/ ……..
12. intrusion ……..
13. confining pressure ……..
14. unloading ……..
15. sheet joint ……..
16. exfoliation ……..
17. frost wedging ……..
18. abrasion /ă-bray-zhŏn/ ……..

19. thermal expansion and contraction ……..
20. dissolution ……..
21. hydrolysis /hÿ-drol-ă-sis/ ……..
22. bedrock ……..
23. fertile soil ……..
24. loam ……..
25. soil profile ……..
26. transitional zone ……..
27. parent rock ……..
28. humus ……..
29. zone of leaching ……..
30. zone of accumulation ……..
31. organic matter ……..
32. topsoil ……..
33. pedalfer /pĕ-dal-fer/ ……..
34. secondary enrichment ……..
35. laterite /lat-ĕ-rÿt/ ……..
36. Pedocal /ped-ŏ-kăl/ ……..

10.3. Reading

WEATHERING, EROSION AND SOIL

What is weathering?

The process of **weathering** alters rocks at the earth's surface and breaks them into fine-grained particles of sediment and soil. Weathering is the result of the interactions of air, water, and temperature on rocks and prepares the rock for erosion.

Erosion is the movement of the particles by ice, wind, or water. The particles are then **transported** by that agent until they are **deposited** to form sedimentary deposits, which can be later eroded again or transformed into sedimentary rocks (Fig. 10-1).

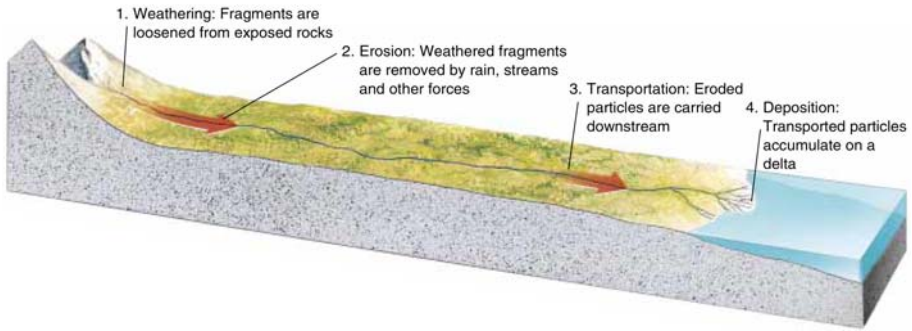


Figure 10-1. A schematic view shows weathering erosion, transport, and deposition of sediment.

Types of weathering

There are two kinds of weathering: mechanical and chemical.

a) Mechanical weathering

Mechanical weathering is the process by which rocks are broken down into smaller pieces by external conditions, such as the freezing of water in cracks in the rock.

Five major processes cause mechanical weathering:

1. **Pressure-release fracturing:** If a large intrusion is brought to the surface through **tectonic uplift** and the erosion of overlying rocks, the confining pressure above the intrusion has been released, but the pressure underneath is still being exerted, forcing the rock to expand. This process is called **unloading** and gives rise to pressure-release fracturing. Because the outer layers expand the most, cracks, or **sheet joints,** develop that parallel the curved outer surface of the rock. Sheet joints become surfaces along which curved pieces of rock break loose, exposing a new surface. This process is called **exfoliation.**
2. **Frost wedging:** Water expands when it freezes. If water accumulates in a crack and then freezes, its expansion pushes the rock apart in a process called **frost wedging**.
3. **Abrasion:** Many rocks along a stream or beach are rounded and smooth. The mechanical wearing and grinding of rock surfaces by friction and impact is called **abrasion.**

4. **Organic activity:** Less important agents of mechanical weathering include the **burrowing of animals, plant roots** that grow in surface cracks, and the digestion of certain minerals, such as metal sulfides, by **bacteria.**
5. **Thermal expansion and contraction:** Daily temperature changes, especially in those regions where temperatures can vary by 30 degrees centigrade, result in the expansion and contraction of minerals, which weaken rocks.

b) Chemical weathering

Chemical weathering occurs when air and water chemically react with rock to alter its composition and mineral content. For example, feldspar crystals in a volcanic tuff commonly weather to form new clay minerals. Other minerals, such as calcite, dissolve. Quartz, on the other hand, is very resistant to weathering.

The most important processes of chemical weathering are dissolution, hydrolysis, and oxidation. Water, carbon dioxide, acids and bases, and oxygen are common substances that cause these processes to decompose rocks.

1. **Dissolution:** A few minerals dissolve readily in water. Acids and bases often markedly increase the solubility of minerals.
2. **Hydrolysis:** During dissolution, a mineral dissolves but does not react chemically with the solution. However, during **hydrolysis**, water reacts with a mineral to form a new mineral with the water incorporated into its crystal structure. Many common minerals weather by hydrolysis. For example, feldspar, the most abundant mineral in the Earth's crust, weathers by hydrolysis to form clay.
3. **Oxidation:** Many elements react with atmospheric oxygen, O_2. Iron rusts when it reacts with water and oxygen. Rusting is one example of a more general process called **oxidation**.

Soils

The layers of weathered particles of earth material that contain organic matter and can support vegetation are defined as **soil.** Soil can be all or

just part of the sedimentary material that covers the bedrock.

Soil commonly consists of sand, silt, clay, and organic material. The most fertile soils contain a mixture of sand, clay, and silt as well as abundant amounts of organic matter. Such a mixture is called **loam**.

Soil profiles

A typical mature soil consists of several layers called **soil horizons**. The uppermost layer is called the **O horizon**, named for its Organic component. This layer consists mostly of litter and humus with a small proportion of minerals (Fig. 10-2).

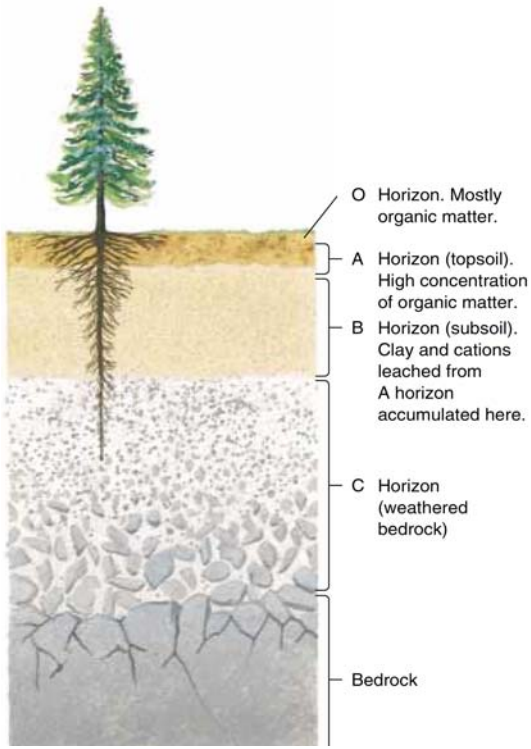


Figure 10-2. Schematic soil profile showing typical soil horizons.

The next layer down, called the **A horizon**, is a mixture of humus, sand, silt, and clay. The combined O and A horizons are called **topsoil**.

The third layer, the **B horizon** or subsoil, is a transitional zone between topsoil and weathered parent rock below. Roots and other

organic material occur in the B horizon, but the total amount of organic matter is low.

The lowest layer, called the **C horizon**, consists of partially weathered rock that grades into unweathered parent rock. This zone contains little organic matter.

A horizon is the **zone of leaching**, and the **B horizon** is the **zone of accumulation**

EXERCISES

10.4. According to the passage, which of the following statements are "true" or "false"? Insert "T" or "F" in the boxes at the right.

1. The lowermost layer of soil horizon is called the O horizon.
2. Fe and Al oxides are the most resistant to leaching.
3. Loam is a fertile soil.
4. B horizon, is a mixture of humus, sand, silt, and clay.
5. During hydrolysis, a mineral dissolves.
6. A and B horizons are called topsoil.

10.5. Choose a, b, c, or d which best completes each item.

1. Which of the following horizons consist of partially weathered rock?
   a) A horizon b) O horizon
   c) B horizon d) C horizon
2. Which of the following zones are named the zone of accumulation?
   a) A horizon b) O horizon

c) B horizon d) C horizon

3. Rusting is formed by the process of ……..
   a) hydrolysis b) oxidation
   c) dissolution d) abrasion
4. Clay minerals are formed by ……..
   a) chemical weathering b) mechanical weathering
   c) unloading d) frost wedging
5. Which of the following processes cause the exfoliation?
   a) sheet joints b) abrasion
   c) frost wedging d) pressure-release fracturing

10.6. Write the answers to the following questions in your own words.

1. Explain the differences among the terms weathering, erosion, transport, and deposition.

……
……
……
……
……
……
……

2. Explain the differences between mechanical weathering and chemical weathering.

……
……
……
……
……
……
……

3. List five processes that cause mechanical weathering.

……
……
……
……
……
……
……

4. Explain how thermal expansion can establish forces that could fracture a rock.

……
……
……
……
……
……
……

10.7. Note the following technical words and their definitions and translate the words into Persian.

Technical words	Definitions
Erode (verb)	To wear away the land, by the action of streams, waves, wind or glaciers.
Eroding (verb)	
Erodible (adjective)	able to be corroded or worn away.
Erodibility (adverb)	The quality, degree or capability of being eroded.
Erosion (noun)	The process of gradual wearing away of the Earth by wind or water.
Erosional (adjective)	Produced by the wearing-away of the land.
Erosibility	Erodibility
Erosive (adjective)	causing erosion
Erode (verb)	To wear away the land, by the action of streams, waves, wind or glaciers.

Now, fill in the blanks with the appropriate words.

1. Most of the drainage basins are composed of highly ..... sedimentary soils.
2. Weathering and ..... of continents carry mud, sand, and salts to the sea.
3. Unconformities are typically buried ..... surfaces that can represent a break in the geologic record of hundreds of millions of years or more.
4. We are not doing anything about the wind, but we can change the ..... of the soil.
5. Sediment-laden water traveling at high speed has tremendous ..... power.
6. Mountains began to rise and steadily .....
7. Streams will usually be braided if they have high bed loads and easily ..... banks.
8. The ..... effect of ocean waves on the shoreline is very important.
9. The processes of ..... reduce mountains to hills, create canyons, valleys, and soils.
10. The continents are ..... at a high rate.
11. Over geologic time, mountain ranges rise and then ..... away.
12. ..... landscapes such as the Grand Canyon have been formed by constant erosion from running water over millions of years.

10.8. Fill in the blanks with the following words and translate the passage into Persian.

"iron", "evaporation", "organic acids", "weathering", "climates", "leaching", "soil", "erosion".

Soil types

Parent rocks form soils the most rapidly in wet, humid

……**1**……. A pedalfer is a B horizon that is high in aluminum and ……**2**……. It develops in response to abundant rainfall, ……**3**……., and strong downward ……**4**…….

Pedocals are formed in arid climates by water drawn upward by subsurface ……**5**……. and capillary action, which often crystallizes hard calcium salts in the ……**6**…….

Laterites are highly leached, residual soils that form in tropical regions. The high temperature and rainfall result in deep and intense ……**7**……. The ……**8**……. is typically bright red and composed of iron and aluminum oxides that are the most resistant to leaching. Valuable metals such as aluminum, copper, silver, gold, nickel, and iron are concentrated in laterites through secondary enrichment and can sometimes be mined economically.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

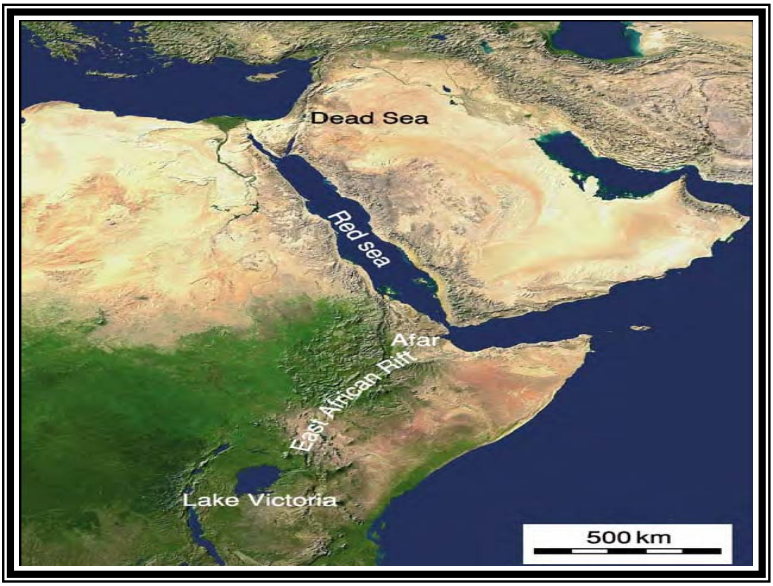
.....

.....

.....

UNIT 11

PLATE TECTONICS



هدف کلی

محتوای اصلی این درس که تحت عنوان Plate tectonics ارائه گردیده است، در خصوص آشنایی با نظریه تکتونیک صفحه‌ای، انواع مرز صفحات تکتونیکی و انواع مکانیسم‌های دخیل در حرکت صفحات و فرورانش می‌باشد. هدف کلی از تدوین این درس، آشنایی دانشجویان با تعدادی از واژه‌ها و اصطلاحات عمومی و واژه‌های کلیدی زمین‌شناسی و نیز کسب مهارت لازم در درک محتوای متن انگلیسی درس می‌باشد.

هدف‌های رفتاری

انتظار می‌رود دانشجو با مطالعه این فصل بتواند:

۱. معنی واژه‌های عام بخش ۱۱–۱ را با استفاده از فرهنگ لغات، مشخص نموده و مترادف و متضاد هر یک از واژه‌ها را بیاموزد.
۲. معنی واژه‌های کلیدی و تخصصی بخش ۱۱–۲ را پس از جستجو در فرهنگ لغات زمین‌شناسی، آموخته و تلفظ صحیح آنها را فرا گیرد.
۳. متن اصلی درس را با دقت مطالعه نموده و درک کلی از مفهوم نظریه تکتونیک صفحه‌ای، انواع مرزهای تکتونیکی (دورشونده، همگرا، ترادیسی) و مکانیسم فرورانش داشته باشد.
۴. با توجه به مفهوم کلی درس، صحیح یا غلط‌بودن عبارات تمرین ۱۱–۴ را مشخص نماید.
۵. با توجه به متن درس، در بخش ۱۱–۵ مناسب‌ترین گزینه را از بین چهار گزینه، انتخاب و علامت‌گذاری نماید.
۶. پاسخ سؤالات بخش ۱۱–۶ را با توجه به مفهوم کلی درس، مشخص نموده و سعی نماید تا بدون استفاده از جمله‌بندی‌های متن درس، سؤالات را جواب دهد.
۷. اقسام کلام (اسم، فعل، قید و صفت) واژه تخصصی Tectonics به همراه تعاریف آنها را آموخته و قادر به به‌کار بردن این واژه‌ها در جملات مختلف تخصصی باشد.
۸. متن انگلیسی بخش ۱۱–۸ را با واژه‌های داده‌شده تکمیل و سپس آن را به فارسی روان ترجمه نماید.
۹. جملات پراکنده دو ستون جدول بخش ۱۱–۹ را تکمیل نماید.

11.1. COMMON WORDS: Note the synonyms and antonyms of following words and translate the words into Persian.

Word	Synonym	Antonym
float	stay on the surface of a liquid	sink
plastic	flexible	rigid
weak	frail	strong
stable	firm	unstable
upward	to a higher level	downward
underlying	lying beneath	overlying
rise	move upward	descend
narrow	restrict	wide

11.2. TECHNICAL WORDS: Note the pronunciation of the following technical words and expressions and translate them into Persian.

1. intrusions ……..
2. faulting ……..
3. folding ……..
4. plate tectonics /tek-tonn-ik/ ……..
5. ocean basins ……..
6. mountain building ……..
7. oceanic trenches ……..
8. plate boundaries ……..
9. divergent plate boundaries ……..
10. spreading centers ……..
11. rift zone ……..
12. mid-oceanic ridge ……..
13. continental rifting ……..
14. convergent plate boundaries ……..
15. oceanic crust ……..
16. continental crust ……..
17. subduction /sub-duk-shŏn/ ……..

18. benioff zone /ben-ee-off/ ……..
19. island arc ……..
20. magmatic arc ……..
21. transform plate boundaries ……..
22. mantle convection ……..

11.3. Reading

PLATE TECTONICS

What is the plate tectonic theory?

Magma generation, igneous intrusions, metamorphism, volcanic action, earthquakes, faulting, and folding are usually the result of plate tectonic activity. The plate tectonics theory is simple. Briefly, it describes the Earth's outer layer, called the lithosphere, as a shell of hard, strong rock. This shell is broken into seven large (and several smaller) segments called tectonic plates. They are also called lithospheric plates (Fig. 11–1).

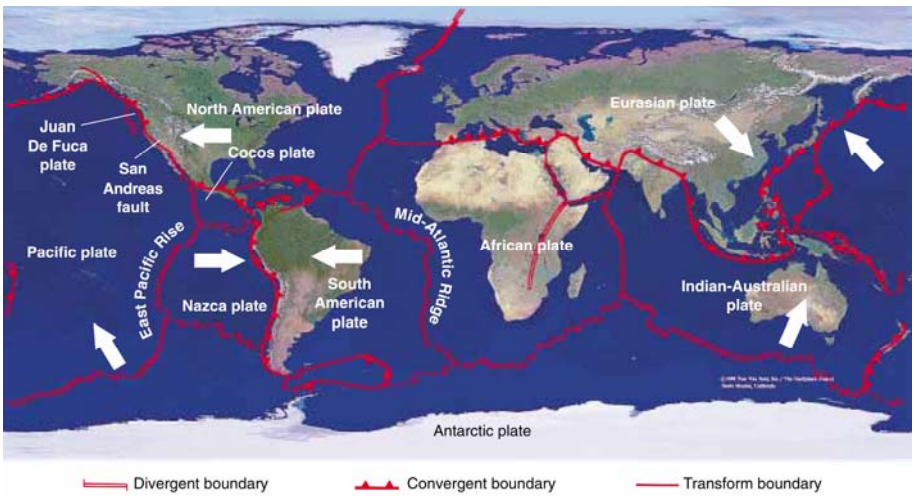


Figure 11–1. The Earth's lithosphere is broken into seven large plates; they are called the African, Eurasian, Indian–Australian, Antarctic, Pacific, North American, and South American plates. A few of the smaller plates are also shown. Arrows indicate directions of plate movement and show that the plates move in different directions.

The tectonic plates float on the layer below, called the asthenosphere. The asthenosphere, like the lithosphere, is rock. But the asthenosphere is so hot that 1 to 2 percent of it is melted. As a result, it is plastic, and weak. The lithospheric plates glide slowly over the asthenosphere like sheets of ice drifting across a pond (Fig. 11–2).

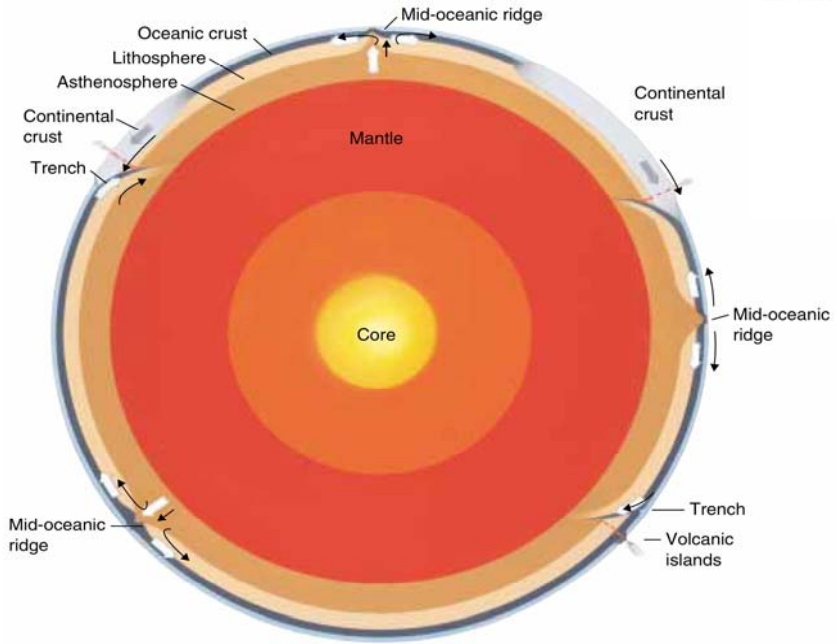


Figure 11-2. Plates of lithosphere glide over the asthenosphere, carrying continents and oceans with them. As a plate moves, old lithosphere sinks in to the Earth's interior at its leadind edge, and new lithosphere forms at the trailing edge.

Continents and ocean basins make up the upper parts of the plates. As a tectonic plate glides over the asthenosphere, the continents and oceans move with it.

Volcanoes, earthquakes, mountain building, and oceanic trenches occur near plate boundaries. Interior parts of lithospheric plates are tectonically stable. Tectonic plates move horizontally at rates that vary from 1 to 16 centimeters per year.

Different types of plate boundaries

Three types of plate boundaries exist (Fig. 11–3):

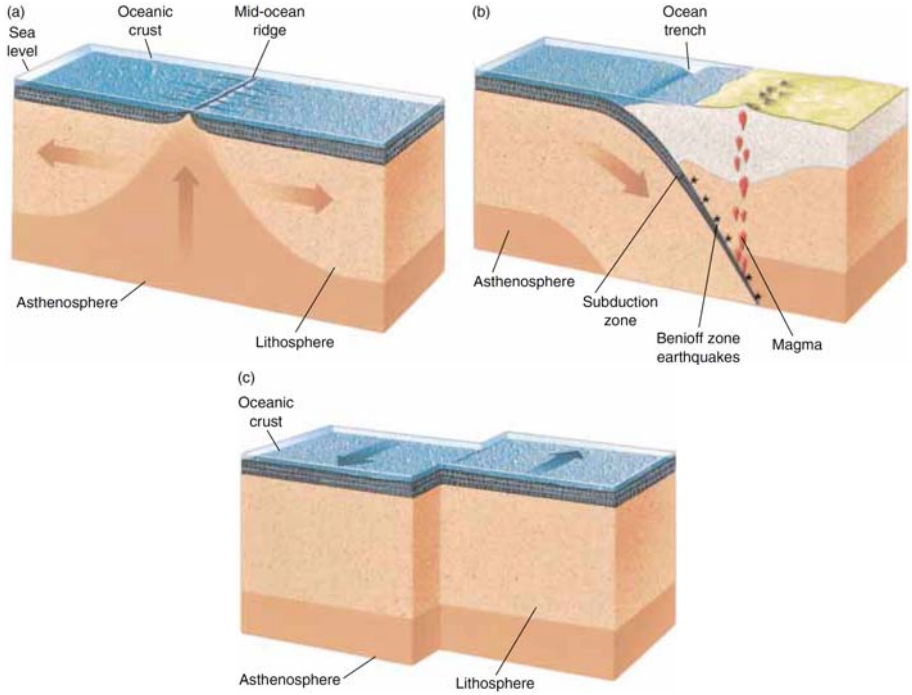


Figure 11–3. Three types of boundaries separate the Earth's tectonic plates: (a) Two plates separate at a divergent boundary. New lithosphere forms as hot asthenosphere rises to fill the gap where the two plates spread apart. (b) Two plates converge at a convergent boundary. If one of the plates carries oceanic crust, the dense oceanic plate sinks into the mantle in a subduction zone. Here an oceanic plate is sinking beneath a less dense continental plate. Magma rises from the subduction zone, and a trench forms where the subducting plate sinks. The stars mark Benioff zone earthquakes that occur as the sinking plate slips past the opposite plate. (c) At a transform plate boundary, rocks on opposite sides of the fracture slide horizontally past each other.

1. **Divergent plate boundaries or spreading centers:** At a divergent plate boundary, also called a spreading center and a rift zone, two lithospheric plates spread apart (Fig. 11-3a). The underlying asthenosphere then flows slowly upward to fill the gap between the separating plates. As the asthenosphere rises between separating plates, some of it melts to form molten rock called magma.

   Most of the magma rises to the Earth's surface, where it cools to form new crust, the top layer of the lithosphere. Most of this activity occurs beneath the seas because most divergent plate boundaries lie in the ocean basins. The sea floor at a spreading center floats to a

high elevation, forming an undersea mountain chain called the mid-oceanic ridge (Fig. 11-3a). The mid-oceanic ridge system is the Earth's longest mountain chain. The basaltic magma that flows slowly onto the sea floor at the ridge creates approximately 6.5×10^{18} (6,500,000,000,000,000,000) tons of new oceanic crust each year.

Moreover, a divergent plate boundary can rip a continent called continental rifting. Continental rifting is now taking place along a zone called the East African rift (Fig. 11-1).

2. **Convergent plate boundaries:** At a convergent plate boundary, two lithospheric plates move toward each other. Convergence can occur:

a) Between a plate carrying oceanic crust and another carrying continental crust,
b) Between two plates carrying oceanic crust,
c) Between two plates carrying continental crust.

When two plates converge, the denser plate enter beneath the lighter one and sinks into the mantle. This process is called subduction. A subduction zone is a long, narrow belt where a lithospheric plate is sinking into the mantle (Fig 11-3b). Oceanic crust, composed mainly of olivine and pyroxene, can be subducted along Benioff zones and recycled back into the mantle. Continental crust is composed dominantly of granites, gneisses, and upper crustal sedimentary rocks. The quartz and feldspar-rich continental crust is weaker and more buoyant, and cannot easily subduct into the denser mantle.

Subduction zones are often marked by overlying chains of volcanic islands called island arcs.

Magmatic arc is a general term for belts of andesitic island arcs and inland andesitic mountain ranges that develop along continental edges.

3. **Transform plate boundaries:** A transform plate boundary forms where two plates slide horizontally past one another as they move in opposite directions (Fig. 11–3c). California's San Andreas Fault is the transform boundary between the North American plate and the Pacific plate. This type of boundary can occur in both oceans and continents.

Mechanisms of plate movement and subduction

Mantle convection may cause plate movement. Alternatively, a plate may move because it slides downhill from a spreading center, as its cold edge sinks into the mantle and drags the rest of the plate along.

EXERCISES

11.4. According to the passage, which of the following statements are "true" or "false"? Insert "T" or "F" in the boxes at the right.

1. Continental rifting is related in to the convergent plate boundaries.
2. The tectonic plates float on the lithosphere.
3. Magmatic arcs are related to subduction.
4. Transform plate boundaries can occur only in oceans.
5. At the mid ocean ridges, the basaltic magma flows onto the sea floor.
6. At a spreading center, two asthenospheric plates spread apart.

1.5. Choose a, b, c, or d which best completes each item.

1. How much of the lithosphere is melted?
   a) 1-2 percent b) 10-20 percent
   c) zero percent d) 1-16 percent
2. Island arcs are related to ……..
   a) mid oceanic ridges b) subduction zones
   c) divergent plate boundaries d) lithospheric plates
3. What is the east African rift?
   a) a divergent plate boundary b) a convergent plate boundary

c) a transform plate boundary d) a subduction zone

4. Where are found the oceanic trenches?
   a) at the mid oceanic ridges b) at the subduction zones
   c) at the transform boundaries d) at the divergent plate boundaries
5. Transform plate boundaries can occur in ……..
   a) oceans b) continents
   c) both oceans and continents d) continental rifting

11.6. Write the answers to the following questions in your own words.

1. Summarize the important aspects of the plate tectonics theory.

……
……
……
……
……
……
……

2. How many major tectonic plates exist? List them.

……
……
……
……
……
……
……

3. Describe the three types of tectonic plate boundaries.

……
……
……
……
……

……..…
……..…

4. Explain why tectonic plate boundaries are geologically active and the interior regions of plates are geologically stable.

……
……
……..……
……..……
……..…
……..…
……..…

11.7. Note the following technical words and their definitions and translate the words into Persian.

Technical words	Definitions
Tectonic (adjective)	Relating to, causing, or resulting from structural deformation of the earth's crust.
Tectonics (noun)	Study of the changes and processes taking place in the Earth's crust.
Tectonically (adverb)	
Tectonism	The structural behavior of an element of the earth's crust.
Tectonite	Any rock whose fabric reflects the history of its deformation.

Now, fill in the blanks with the appropriate words.

1. In contrast with ..... deformation, 'superficial' deformation of the crust, such as landsliding occurs abruptly.
2. Many lakes in ..... active or volcanic regions are influenced by hydrothermal springs
3. Some ophiolites comprise of ..... harzburgite.

4. To understand the genesis of sequence-stratigraphic units, three essential factors need to be considered: sea-level change, ..., and sediment supply.
5. Some of Precambrian ore deposits have undergone significant .....
6. Ophiolites are fragments of oceanic crust that have been ..... emplaced onto continental margins.

11.8. Fill in the blanks with the following words and translate the passage into Persian.
"ice", "crust", "lithosphere", "interior", "volcanoes", "plate", "mantle", "oceanic", "hard", "plastic", "continent", "earth".

The anatomy of a tectonic plate

The nature of a tectonic plate can be summarized as follows:

1. A plate is a segment of the ……**1**……; thus, it includes the uppermost ……**2**…… and all of the overlying ……**3**…….
2. A single plate can carry both oceanic and continental crust. The average thickness of lithosphere covered by ……**4**……. crust is 75 kilometers, whereas that of lithosphere covered by a ……**5**……. is 125 kilometers. Lithosphere may be as little as 10 to 15 kilometers thick at an oceanic spreading center.
3. A plate is composed of ……**6**……., mechanically strong rock.
4. A plate floats on the underlying hot, ……**7**……. asthenosphere and glides horizontally over it.
5. A plate behaves like a large slab of ……**8**……. floating on a pond. It may flex slightly, as thin ice does when a skater goes by, allowing minor vertical movements. In general, however, each plate moves as a large, intact sheet of rock.
6. A plate margin is tectonically active. Earthquakes and ……**9**……. are common at plate boundaries. In contrast, the ……**10**……. of a lithospheric plate is normally tectonically stable.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

11.9. Match the sentence parts to form a complete sentence.

1. At transform-fault boundaries	A) plates move apart.
2. At divergent boundaries	B) a lithospheric plate is sinking into the mantle.
3. At convergent boundaries	C) plates slide horizontally past each other.
4. At a subduction zone	D) the basaltic magma flows.
5. At the mid-ocean ridges	E) plates come together.

1—— 2—— 3—— 4—— 5——

UNIT 12

GROUND WATER

هدف کلی

محتوای اصلی این درس که تحت عنوان Ground water ارائه گردیده است، در خصوص منشأ، مشخصات و آثاری که جریانات آب‌های زیرزمینی برجای می‌گذارند بحث می‌کند. هدف کلی از تدوین این درس، آشنایی دانشجویان با تعدادی از واژه‌ها و اصطلاحات عمومی و واژه‌های کلیدی زمین‌شناسی و نیز کسب مهارت لازم در درک محتوای متن انگلیسی درس می‌باشد.

هدف‌های رفتاری

انتظار می‌رود دانشجو با مطالعه این فصل بتواند:

۱. معنی واژه‌های عام بخش ۱۲–۱ را با استفاده از فرهنگ لغات، مشخص نموده و مترادف و متضاد هر یک از واژه‌ها را بیاموزد.
۲. معنی واژه‌های کلیدی و تخصصی بخش ۱۲–۲ را پس از جستجو در فرهنگ لغات زمین‌شناسی، آموخته و تلفظ صحیح آنها را فرا گیرد.
۳. متن اصلی درس را با دقت مطالعه نموده و درک کلی از مفهوم آب زیرزمینی، نحوه تشکیل و پدیده‌های تشکیل‌شده در اثر جریان آب‌های زیرزمینی نظیر غارها، ژیزرها و چاله‌های ریزشی داشته باشد.
۴. با توجه به مفهوم کلی درس، صحیح یا غلط‌بودن عبارات تمرین ۱۲–۴ را مشخص نماید.
۵. با توجه به متن درس، در بخش ۱۲–۵ مناسب‌ترین گزینه را از بین چهار گزینه، انتخاب و علامت‌گذاری نماید.
۶. پاسخ سؤالات بخش ۱۲–۶ را با توجه به مفهوم کلی درس، مشخص نموده و سعی نماید تا بدون استفاده از جمله‌بندی‌های متن درس، سؤالات را پاسخ دهد.
۷. اقسام کلام (اسم، فعل، قید و صفت) واژه تخصصی Explosion به همراه تعاریف آنها را آموخته و قادر به به‌کار بردن این واژه‌ها در جملات مختلف تخصصی باشد.
۸. با استفاده از واژه‌های داده‌شده، شکل مربوط یه سیستم آب‌های زیرزمینی (بخش ۱۲–۸) را تکمیل نماید.

12.1. COMMON WORDS: Note the synonyms and antonyms of following words and translate the words into Persian.

Word	Synonym	Antonym
fresh water	not salty water	salty water
contrast	compare	similarity
moist	wet	dry
withdrawn from	extract from	insert to
settle	move down	rise
numerous	very many	few

12.2. TECHNICAL WORDS: Note the pronunciation of the following technical words and expressions and translate them into Persian.

1. ground water ……..
2. percolation /per-kŏ-lay-shŏn/ ……..
3. fresh water ……..
4. porosity ……..
5. permeability /per-mee-ă-bil-ă-tee/ ……..
6. water table ……..
7. saturated zone ……..
8. saturation zone ……..
9. unsaturated zone ……..
10. zone of aeration ……..
11. aquifer /ak-wă-fer/ ……..
12. well ……..
13. cone of depression ……..
14. subsidence ……..
15. salt-water intrusion ……..
16. cave ……..
17. stalactite ……..
18. stalagmite ……..

19. column ……..
20. sinkhole ……..
21. karst topography ……..
22. hot spring ……..
23. geyser /gÿ-zer, -ser/ ……..
24. fumaroles /fyoo-mă-rohl/ ……..
25. geothermal energy /jee-oh-th'er-măl/ ……..

12.3. Reading

GROUND WATER

Origin of ground water

Much of the rain that falls on land seeps into soil and bedrock to become **ground water**. More than 90 percent of the liquid **fresh water** available on or near the earth's surface is groundwater. Hot groundwater can also be a source of energy.

Groundwater is derived from rain and melting snow that percolate downward from the surface. The process of percolation is called **infiltration.** Most ground water moves slowly, about 4 centimeters per day.

Characteristics of ground water

In the upper few kilometers of the Earth, bedrock and soil contain small cracks and voids that are filled with air or ground water. The proportional volume of these open spaces is called the **porosity** of rock or soil. The porosity of sand and gravel is typically high, 40 percent or higher.

Porosity indicates the amount of water that rock or soil can hold. In contrast, **permeability** is the ability of rock or soil to transmit water (or any other fluid).

Ground water saturates the upper few kilometers of soil and bedrock to a level called the **water table**. The rock and soil in which

all the open spaces are filled with water is called the **saturated** (or **saturation) zone.** The **water table** is the top of the zone of saturation (Fig. 12–1).

Above the water table lies the **unsaturated zone**, or **zone of aeration** (Fig. 12–1). In this layer, the rock or soil may be moist but not saturated. An **aquifer** is a body of rock that can provide economically significant quantities of water. An aquifer is both porous and permeable.

If you dig into the unsaturated zone, the hole does not fill with water. However, if you dig below the water table into the zone of saturation, you have dug a **well**, and the water level in a well is at the level of the water table (Fig. 12–1).

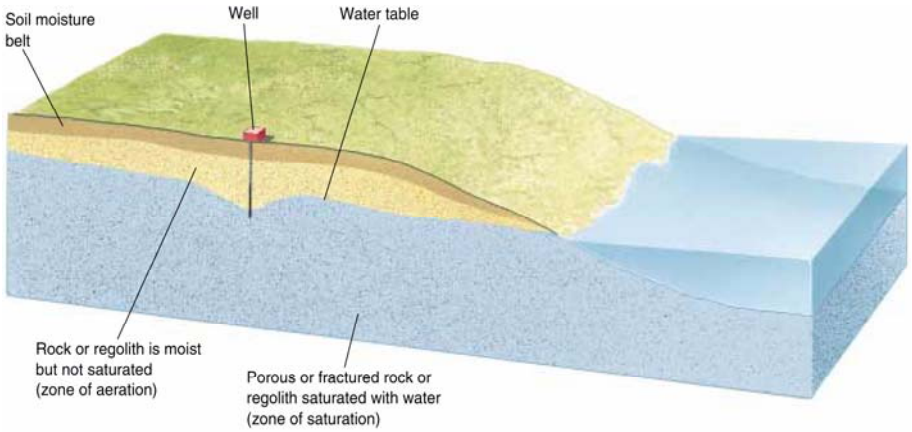


Figure 12-1. The water table is the top of the zone of saturation near the Earth's surface. It intersects the land surface at lakes and streams and is the level of standing water in a well.

If water is withdrawn from a well faster than it can be replaced by the aquifer, a **cone of depression** forms. If rapid withdrawal continues, the water table falls.

Other effects of excessive removal of ground water include **subsidence** of the land and **salt-water intrusion** near a seacoast.

a) Subsidence: Excessive removal of ground water can cause subsidence, the sinking or settling of the Earth's surface.

b) Salt-water intrusion: Two types of ground water are found in coastal areas: fresh water and salty water that seeps in from the sea.

Fresh water floats on top of salty water because it is less dense. If too much fresh water is pumped to the surface, the salty water rises into the aquifer and contaminates wells.

Effects of groundwater flow

The dissolution of calcite from limestone by slightly acidic groundwater results in the gradual widening of joints that may develop into openings, or **caves**. Most caves develop below the water table.

The groundwater that percolates through the cracks in the cave contains calcium and bicarbonate from the dissolution of limestone.

As the water drops from the cave's ceiling, CO_2 gas is released and a small amount of calcite crystallizes where the drop is attached to the ceiling. More CO_2 is lost from the water when the drop hits the floor, causing more calcite to precipitate. By this process, stalactites and stalagmites form. **Stalactites** hang from cave ceilings; **stalagmites** are cone-shaped masses that build up on cave floors. A **column** results when stalactites and stalagmites grow long enough to join into one structure.

A **sinkhole** forms when the roof of a limestone cavern collapses (Fig. 12-2). **Karst topography**, with numerous caves, sinkholes, and underground streams, is characteristic of limestone regions.

Hot springs develop when hot ground water rises to the surface. Ground water can be heated by: (1) the geothermal gradient, (2) shallow magma or a cooling pluton, and (3) chemical reactions between ground water and sulfide minerals.

A **geyser** is a more explosive hot spring that periodically erupts extremely hot water and steam. **Fumaroles** are vents from which steam and other gases escape.

Hot ground water can be used to drive turbines and generate electricity, or it can be used directly to heat homes and other buildings. Energy extracted from the Earth’s heat is called **geothermal energy**.

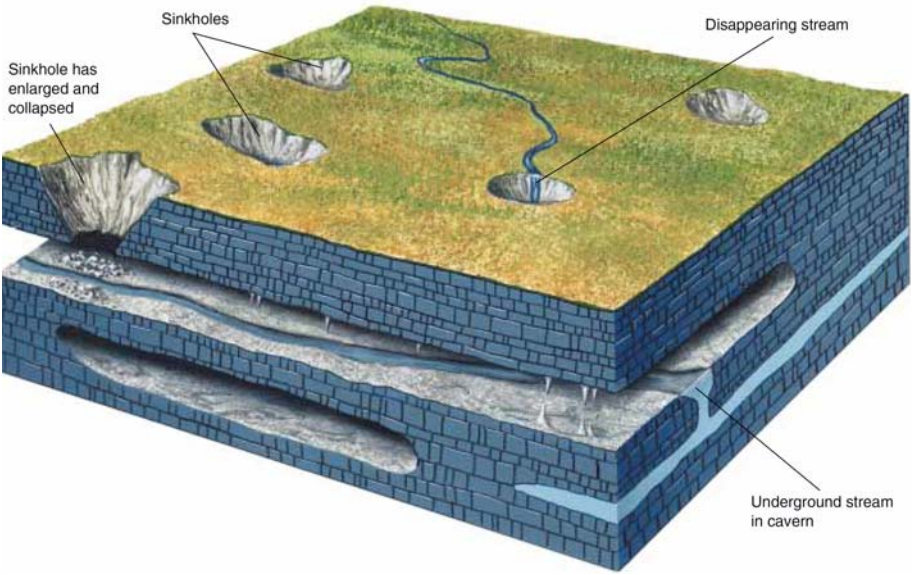


Figure 12-2. Sinkholes and caverns form in limestone. Streams commonly disappear into sinkholes and flow through the caverns to emerge elsewhere.

EXERCISES

12.4. According to the passage, which of the following statements are "true" or "false"? Insert "T" or "F" in the boxes at the right.

1. Stalagmites hang from cave ceilings.

2. A sinkhole forms when the roof of a limestone cavern collapses.

3. Most caves develop over the water table.

4. Subsidence formed due to excessive removal of ground water.

5. The saturated zone lies above the water table.

6. Salt-water intrusion contaminates wells.

12.5. Choose a, b, c, or d which best completes each item.

1. What is named the proportion of rock or soil that consists of open space?
   a) Permeability b) Porosity
   c) Aquifer d) Saturation
2. What is the effect of excessive removal of ground water?
   a) cone of depression b) subsidence of the land
   c) salt-water intrusion d) all answers
3. What is a geyser?
   a) Is hot ground water which rises to the surface.
   b) Is vent from which steam and other gases escape.
   c) Is an explosive hot spring that periodically erupts extremely hot water and steam.
   d) Is a body of rock that can provide economically significant quantities of water.
4. When a cone of depression forms?
   a) If rapid withdrawal continues.
   b) If water is withdrawn from a well faster than it can be replaced by the aquifer.
   c) If water is withdrawn from a well slower than it can be replaced by the aquifer.
   d) If the water level in a well was at the level of the water table.
5. What is formed when stalactites and stalagmites join into one structure?
   a) column b) karst topography
   c) sinkhole d)cavern

12.6. Write the answers to the following questions in your own words.

1. Describe the difference between porosity and permeability.

……
……
……

……
……
……
……

2. (a) Draw a cross section showing the zone of saturation, water table, and zone of aeration. (b) Explain each of these terms.

……
……
……
……
……
……
……

3. What is an aquifer, and how does water reach it?

……
……
……
……
……
……
……

4. Describe three types of heat source for a hot spring.

……
……
……
……
……
……
……

12.7. Note the following technical words and their definitions and translate the words into Persian.

Technical words	Definitions
Explode (verb)	blow up; be blown up
Exploding (noun)	blowing up; shattering, breaking into pieces
Explosive (adjective)	responsible to blow up
Explosively (adverb)	in an explosive manner
Explosion (noun)	act of exploding

Now, fill in the blanks with the appropriate words.

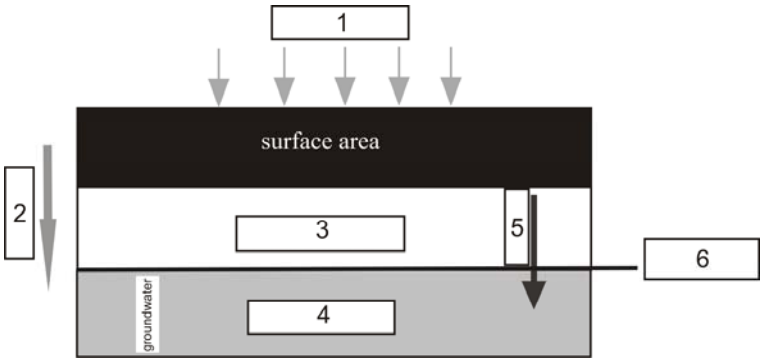
1. Pyroclastic rock made up of material ejected ..... from a volcanic vent.
2. Caldera is a large circular depression caused by an ..... volcanic eruption.
3. Seismic waves are elastic waves that travel through rock, produced by an earthquake or .....
4. Magma may flow onto the Earth's surface as lava or may erupt ..... as pyroclastic material.
5. The gas-rich magma ..... through fractures, rising as a vertical column of hot ash, rock fragments, and gas.
6. After an eruption, upper layers of the remaining magma are depleted in gas and the ..... potential is low.
7. The cloud that made our solar system formed from matter ejected from an ..... star.

12.8. Form four separate sentences from the sentence parts.

Porosity	is porous, permeable, saturated formations of rock	dotted with numerous sinkholes and depressions
Aquifer	is an irregular land surface	that consists of voids
Karst topography	is the ease with which fluid is transmitted	through a rock's pore space
Permeability	is the percentage of a rock	that transmit groundwater easily

1. ……..……..
2. ……..……..
3. ……..……..
4. ……..……..

12.9. Note the following simplified diagram of the groundwater system and complete the blank with the appropriate words listed below. “unsaturated area”, “saturated area”, “gravity”, “precipitation”, “water table”, “percolation”, “groundwater”.



UNIT 13

GEOHAZARDS

هدف کلی

محتوای اصلی این درس که تحت عنوان Geohazards ارائه گردیده است، در خصوص انواع مخاطرات زمین‌شناسی بحث می‌کند. هدف کلی از تدوین این درس، آشنایی دانشجویان با تعدادی از واژه‌ها و اصطلاحات عمومی و واژه‌های کلیدی زمین‌شناسی و نیز کسب مهارت لازم در درک محتوای متن انگلیسی درس می‌باشد.

هدف‌های رفتاری

انتظار می‌رود دانشجو با مطالعه این فصل بتواند:

۱. معنی واژه‌های عام بخش ۱۳-۱ را با استفاده از فرهنگ لغات، مشخص نموده و

مترادف و متضاد هر یک از واژه‌ها را بیاموزد.

۲. معنی واژه‌های کلیدی و تخصصی بخش ۱۳-۲ را پس از جستجو در فرهنگ لغات زمین‌شناسی، آموخته و تلفظ صحیح آنها را فرا گیرد.

۳. متن اصلی درس را با دقت مطالعه نموده و درک کلی از مفهوم مخاطرات زمین‌شناسی و انواع آنها نظیر تسونامی، زمین‌لغزه و غیره داشته باشد.

۴. با توجه به مفهوم کلی درس، صحیح یا غلط‌بودن عبارات تمرین ۱۳-۴ را مشخص نماید.

۵. با توجه به متن درس، در بخش ۱۳-۵ مناسب‌ترین گزینه را از بین چهار گزینه، انتخاب و علامت‌گذاری نماید.

۶. متن انگلیسی بخش ۱۳-۶ را با واژه‌های داده شده تکمیل و سپس آن را به فارسی روان ترجمه نماید.

۷. انواع مخاطرات زمین‌شناسی و تعاریف آنها را با یکدیگر جور نماید (بخش ۱۳-۷).

13.1. COMMON WORDS: Note the synonyms and antonyms of following words and translate the words into Persian.

Word	Synonym	Antonym
harm	damage	benefit
expansion	enlargement	contraction
constantly	continuously	occasionally
suddenly	rapidly	gradually
distant	remote	near
disaster	catastrophe	success
wealth	richness	poverty

13.2. TECHNICAL WORDS: Note the pronunciation of the following technical words and expressions and translate them into Persian.

1. geohazard ……..
2. hazard ……..
3. planet ……..
4. earthquake ……..
5. landslide ……..
6. tsunamis /tsoo-nah-mee/ ……..
7. subsidence ……..
8. coastal progradation ……..
9. expansive soils ……..
10. creep ……..
11. hazardous ……..
12. ash ……..
13. collapse ……..
14. impact ……..
15. uplift ……..
16. flood ……..
17. extraterrestrial ……..
18. meteorite ……..

19. asteroid ……..
20. mountain belt ……..

13.3. Reading

GEOHAZARDS

What are geohazards?

Hazard is a natural or man-made event or condition that has the potential to cause harm or loss to humans and/or damage to the natural and built environment. There are two definitions of geohazards:

1. A geohazard is a hazard of geological, hydrological nature which poses a threat to Man and his activities.
2. A geohazard is one that involves the interaction of man and any natural process on the planet.

Types of natural geohazards

Natural geologic processes are in constant operation on the planet. These processes are considered hazardous when they go to extremes and interfere with the normal activities of society. For instance, the surface of the Earth is constantly moving through plate tectonics, yet we do not notice this process until sections of the surface move suddenly and cause an earthquake.

The geological hazards take many shapes and forms, from violent earthquakes to the slow downhill creep of material on a hillside and the expansion of clay minerals in wet seasons. The principal natural geohazards are:

1. earthquakes (rapid hazards)
2. volcanic eruptions (rapid hazards)
3. landslides (rapid hazards)
4. tsunamis (rapid hazards)
5. subsidence (slow hazards)
6. coastal erosion (slow hazards)

7. coastal progradation (slow hazards)
8. soil erosion (slow hazards)
9. expansive soils (slow hazards)

The Earth is a naturally dynamic and hazardous world, with volcanic eruptions ejecting lava and ash, earthquakes pushing up mountains and shaking Earth's surface, and tsunami that sweep across ocean basins at hundred of miles per hour, rising in huge waves on distant shores. Mountains may suddenly collapse, burying entire villages, and slopes are gradually creeping downhill moving everything built on them. Storms sweep coastlines and remove millions of tons of sand from one place and deposit it in another in single days.

The slow but steady movement of tectonic plates on the surface of the Earth is the cause of many geologic hazards, either directly or indirectly. Plate tectonics controls the distribution of earthquakes and the location of volcanoes and causes mountains to be uplifted. Other hazards are related to Earth's surface processes, including floods of rivers, coastal erosion, and changing climate zones.

Many of Earth's surface processes are parts of natural cycles on the Earth, but they are considered hazardous to humans because we have not adequately understood the cycles before building on exposed coastlines and in areas prone to shifting climate zones.

A third group of geologic hazards is related to materials, such as clay minerals that dramatically expand when wetted, and sinkholes that develop in limestones.

Still other hazards are extraterrestrial in origin, such as the occasional impact of meteorites and asteroids with Earth. The exponentially growing human population on Earth worsens the effect of most of these hazards.

Most of the earthquakes on the planet are directly associated with plate boundaries. Single earthquakes have killed tens and even hundreds of thousands of people, such as the 1976 Tangshan earthquake in China that killed a quarter million people.

Most of the world's volcanoes are also associated with plate

boundaries. Those volcanoes which situated above subduction zones at convergent boundaries are capable of producing tremendous explosive eruptions. Volcanic eruptions and associated phenomena have killed tens of thousands of people in this century, including the massive mudslides at Nevada del Ruiz in Colombia that killed 23,000 in 1985.

Plate tectonics is also responsible for uplifting the world's mountain belts, which are associated with their own sets of hazards, particularly landslides and other mass wasting phenomena.

Some geologic hazards are associated with steep slopes, and the effects of gravity moving material down these steep slopes to places where people live. Landslides and the slow downhill movement of earth material occasionally kill thousands of people in large disasters, such as when parts of a mountain collapsed in 1970 in the Peruvian Andes and buried a village several tens of miles away, killing 60,000 people.

Coastal subsidence coupled with gradual sea-level rise is rapidly becoming one of the major global hazards that the human race is going to have to deal with in the next century, since most of the world's population lives near the coast in the reach of the rising waters. Cities may become submerged and farmlands covered by shallow salty seas. An enormous amount of planning is needed, as soon as possible, to begin to deal with this growing threat.

Geologic hazards can be extremely costly, in terms of price and human casualties. With growing population and wealth, the cost of natural disasters has grown as well. The costs of natural geologic hazards are now similar to the costs of warfare demonstrates the importance of their causes and potential effects.

Some of the above mentioned geologic hazards (such as earthquakes and volcanoes) will be discussed in later units.

EXERCISES

13.4. According to the passage, which of the following statements are "true" or "false"? Insert "T" or "F" in the boxes at the right.

1. Plate tectonics controls the coastal erosion.

2. All of the world's volcanoes and earthquakes are associated with plate boundaries.

3. Tsunamis are classified among rapid hazards.

4. Volcanoes at divergent boundaries are capable of producing tremendous explosive eruptions.

13.5. Choose a, b, c, or d which best completes each item.

1. Which of the following geohazards classify in rapid types?
   a) soil erosion b) landslides
   c) subsidence d) expansive soils
2. Which of the following items are related to plate tectonic?
   a) earthquakes b) volcanoes
   c) mountains uplift d) all answers
3. Which of the geologic hazards are associated with steep slopes?
   a) soil erosion b) expansion soil
   c) subsidence d) landslides
4. Which of the following hazards are related to Earth's surface processes?
   a) coastal erosion b) volcanoes
   c) mountains uplift d) all answers

13.6. Fill in the blanks with the following words and translate the passage into Persian.

"subduction zone", "ocean", "epicenter", "volcanic", "underwater", "earthquakes", "lithospheric".

Tsunami

If the sea floor suddenly shifts upward or downward, the sudden displacement of water results in seismic sea waves, or tsunamis. Tsunami generated in the ……**1**…… by submarine ……**2**……., explosive ……**3**……. eruptions, or mass slides ……**4**……. Although fairly rare, such waves can have catastrophic effects when they do occur. Perhaps of limited height (about a meter) in the open ocean, they may travel hundreds or even thousands of kilometers, and they attain considerable heights (up to tens of meters) in shallow coastal water and at breakpoint.

Their length at sea may be 150 km or more, and they usually travel at high speeds, probably between 500 and 1000 km per hour. They have caused immense havoc and destruction and heavy loss of life, especially along low-lying coasts. The catastrophic Asian tsunami of December 26, 2004, which resulted in over 283,000 deaths and considerable damage, was caused by a massive earthquake of magnitude 9 that had its ……**5**……. 30 km below the seafloor, 250 km south-southeast of Banda Aceh, Indonesia. It occurred as a 1200-km stretch of the Indian ……**6**……. (tectonic) plate was thrust some 20 m under the Burma plate, the thrust-faulting releasing elastic strains that had accumulated in the ……**7**……., and raising the seafloor by several meters. The consequent tsunami waves caused damage along the coastlines of 13 countries including Indonesia (with waves up to 10 m high on the coastline of Sumatra), Sri Lanka, India, Thailand, Myanmar, Malaysia, The Maldives, and the East African countries of Somalia and Kenya.

.....

.....

.....

.....

.....

.....

.....

.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....

13.7. Match the technical words to their definitions.

Technical word	Definition
1. coastline	A) A solid body that has fallen to the Earth's surface from an extraterrestrial source.
2. landslide	B) small object that orbits the sun
3. meteorite	C) The landward limit of the beach, the boundary between the coast and the shore, or the line that forms the boundary between the land and the water.
4. creep	D) The state of a river when the water commences to spread away from the channel.

5. flood	E) The slow movement of soil and rock debris down gentle slopes under the influence of gravity:
6. asteroid	F) The sudden downslope movement of rock and debris due to failure along a shear plane
7. Transport	G) Water below the surface and its location in different soil layers and gaps.

1—— 2—— 3—— 4—— 5—— 6—— 7——

UNIT 14

VOLCANOES AND LAVAS

هدف کلی

محتوای اصلی این درس که تحت عنوان Volcanoes and lavas ارائه گردیده است، در خصوص آشنایی با انواع آتشفشان‌ها، بخش‌های مختلف آنها و انواع اشکال گدازه‌ها می‌باشد. هدف کلی از تدوین این درس، آشنایی دانشجویان با تعدادی از واژه‌ها و اصطلاحات عمومی و واژه‌های کلیدی زمین‌شناسی و نیز کسب مهارت لازم در درک محتوای متن انگلیسی درس می‌باشد.

هدف‌های رفتاری

انتظار می‌رود دانشجو با مطالعه این فصل بتواند:

۱. معنی واژه‌های عام بخش ۱۴–۱ را با استفاده از فرهنگ لغات، مشخص نموده و مترادف و متضاد هر یک از واژه‌ها را بیاموزد.
۲. معنی واژه‌های کلیدی و تخصصی بخش ۱۴–۲ را پس از جستجو در فرهنگ لغات زمین‌شناسی، آموخته و تلفظ صحیح آنها را فرا گیرد.
۳. متن اصلی درس را با دقت مطالعه نموده و درک کلی از مفهوم گدازه، آتشفشان، انواع آتشفشان و گدازه داشته باشد.
۴. با توجه به مفهوم کلی درس، صحیح یا غلط‌بودن عبارات تمرین ۱۴–۴ را مشخص نماید.
۵. با توجه به متن درس، در بخش ۱۴–۵ مناسب‌ترین گزینه را از بین چهار گزینه، انتخاب و علامت‌گذاری نماید.
۶. پاسخ سؤالات بخش ۱۴–۶ را با توجه به مفهوم کلی درس، مشخص نموده و سعی نماید تا بدون استفاده از جمله‌بندی‌های متن درس، سؤالات را جواب دهد.
۷. اقسام کلام (اسم، فعل، قید و صفت) واژه تخصصی Volcano به همراه تعاریف آنها را آموخته و قادر به به‌کار بردن این واژه‌ها در جملات مختلف تخصصی باشد.
۸. انواع سنگ‌ها و ساختمان‌های آتشفشانی و تعاریف آنها را با یکدیگر جور نماید (بخش ۱۴–۸).

14.1. COMMON WORDS: Note the synonyms and antonyms of following words and translate the words into Persian.

Word	Synonym	Antonym
summit	highest point, peak	base
destroy	demolish	build
violent	strong	gentle
easily	Without difficulty	difficulty
quickly	rapidly	slowly
steep	having a sharp slope	gentle

14.2. TECHNICAL WORDS: Note the pronunciation of the following technical words and expressions and translate them into Persian.

1. volcanism /vol-kă-niz-ăm/ ……..
2. volcanic activity ……..
3. volcano ……..
4. volcanicity /vol-kă-niss-ă-tee/ ……..
5. volcanology /vol-kă-nol-ŏ-jee/ ……..
6. pyroclast /pÿ-rŏ-klast/ ……..
7. pyroclastic debris /pÿ-rŏ-klass-tik/ ……..
8. pyroclastic flow ……..
9. crater ……..
10. caldera /kal-deer-yă, -dair-/ ……..
11. circular depression ……..
12. summit ……..
13. magma chamber /mag-mă/ ……..
14. composite volcano ……..
15. stratovolcano /stray-toh-vol-kay-noh/ ……..
16. eruption ……..
17. shield volcano ……..
18. viscosity ……..

19. cinder cone ……..
20. pyroclastic cone ……..
21. volcanic dome ……..
22. volcanic vent ……..
23. lava flood ……..
24. plateau basalt /bă-sawlt, bass-awlt/ ……..
25. fragmental textures ……..
26. ash ……..
27. lapilli /lă-pil-ÿ/ ……..
28. bomb ……..
29. block ……..
30. tuff ……..
31. columnar structure ……..
32. columnar joint ……..
33. pillow structure ……..
34. pipe ……..
35. volcanic neck ……..

14.3. Reading

VOLCANOES AND LAVAS

What is a volcano?

Volcanism, or **volcanic activity**, is the venting of liquid magma at the surface of the earth. **Volcanoes** are hills or mountains that form around the vent and consist of cooled magma, rock fragments, and dust from the eruptions. Volcanoes differ widely in shape, structure, and size.

Pieces of rock that are blown out of a volcano are called **pyroclasts** or **pyroclastic debris**. **Pyroclastic flows** are dense, cloudlike mixtures of hot gas and pyroclastic debris that flow down a volcano's sides like an avalanche. These flows can be especially deadly for example, 30,000 people were killed by a pyroclastic flow on the Caribbean island of Martinique in 1902.

Craters and calderas

The **crater** is the circular **depression** at the top of the volcano (Fig. 14-1). A **caldera** is a larger depression at least 1 kilometer in diameter that forms at the top of the volcano when the **summit** is destroyed during an eruption or when the crater floor collapses into the **magma chamber** below.

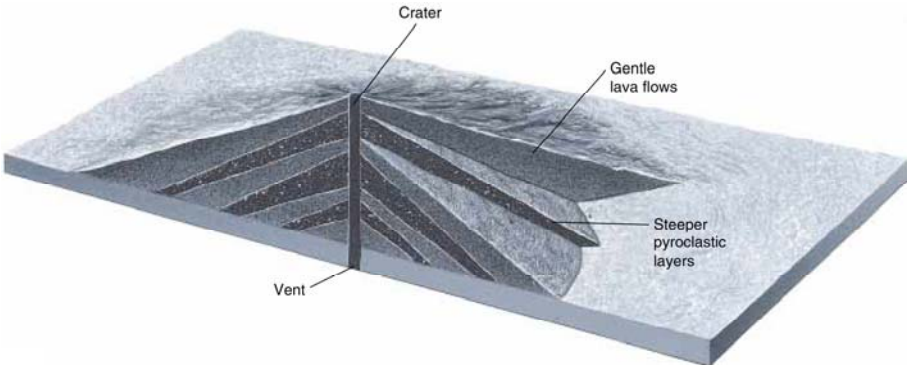


Figure 14-1. A schematic cross section of a composite cone showing alternating layers of lava and pyroclastic material.

Types of volcanoes

There are three kinds of volcanoes: composite, shield, and cinder cone.

a) Composite volcanoes (stratovolcanoes) have been the sources of some of the more famous and destructive eruptions, such as those of Mount St. Helens, Vesuvius, and Damavand. Built up over millions of years, they consist of alternating layers of lava and pyroclastic debris that can approach slopes as steep as 45 degrees (Fig. 14-1). They are characterized by long periods of inactivity that can last for up to hundreds of thousands of years. How violent an eruption is depends on the temperature of the lava and the amounts of silica and dissolved gas in the lava.

b) Shield volcanoes are broad, cone-shaped hills or mountains made from cooled lava flows. The sides are very gently dipping and rarely exceed 10 degrees from the horizontal because the lavas have a low **viscosity** and spread quickly after eruption. **(Viscosity** is defined as resistance to flow; a lava with high viscosity flows slowly)

c) A **cinder cone (pyroclastic cone)** is composed of pyroclastic material (not lavas) ejected from a **vent** and commonly has slopes of about 30 degrees.

Volcanic domes

If a magma is thick and viscous and does not easily flow, it may form a **volcanic dome.** Volcanic domes are steep sided or rounded and form near the volcanic vent.

Lava floods

Nonvolcanic lavas called **lava floods** or **plateau basalts** are often associated with deep cracks in the continental crust.

The lithification of ejected rock fragments and other pyroclastic material creates a variety of **fragmental** textures. **Dust** and **ash** are the finest-grained particles, followed by **cinders** (pea sized), **lapilli** (walnut sized), and **bombs** or **blocks,** which can be up to a meter across or larger. A **tuff** is composed of fine-grained pyroclastic material.

One distinctive extrusive rock texture occurs in flood basalts and submarine lava flows. Flood basalts cool and contract to form vertical, parallel, generally six-sided columns called **columnar structures** or **columnar jointing** (Figure 14-2). As a submarine lava flow cools, blobs of lava may break through the exterior and harden immediately in the cold water, forming small rounded shapes called **pillow structures**. These are especially useful to the geologist for determining that the rock was formed on the ocean floor and for indicating the base of the flow.

Volcanic necks and pipes

A **volcanic neck** is the rock that formed in the vent of a volcano at the end of its eruptive life. It remains "standing" after the flanks of the volcano have eroded away.

In some locations, cylindrical dikes called **pipes** extend from the asthenosphere to the Earth’s surface. They are conduits that once carried magma on its way to erupt from a volcano, but they are now

filled with solidified magma.

An unusual type of pipe contains a rock called **kimberlite**, which is the only known source of diamonds.

Figure 14-2. Columnar joints.

EXERCISES

14.4. According to the passage, which of the following statements are "true" or "false"? Insert "T" or "F" in the boxes at the right.

1. Columnar structures form in the cold water.
2. Kimberlites are cylindrical dikes.
3. Lava is the main constituents of a cinder cone.
4. Cinder cones are often associated with deep cracks in the continental crust.
5. Pyroclastic flows are mixtures of gas and lava.

14.5. Choose a, b, c, or d which best completes each item.

1. What is named a small volcano composed of pyroclastic fragments?
   a) Shield volcano b) Cinder cone
   c) Composite volcano d) Stratovolcano
2. Which of the following structures are useful for indicating the base of the flow?
   a) Columnal joints b) Pillow structures
   c) Cinder cones d) Pyroclastic flows
3. Which of the following particle is the smallest one?
   a) Bomb b) Lapilli
   c) Cinder d) Block
4. What is named the circular depression at the top of the volcano?
   a) Crater b) Vent
   c) Caldera d) Cone
5. Which of the following rocks are associated with deep cracks in the continental crust?
   a) Kimberlites b) Pillow structures
   c) Pyroclastic flows d) Plateau basalts

14.6. Write the answers to the following questions in your own words.

1. How do a shield volcano, a cinder cone, and a composite cone differ from one another?

……
……
……
……
……
……
……

2. What is a volcanic neck? How is it formed?

……
……
……
……
……
……
……

3. What is a caldera? How is it formed?

……
……
……
……
……
……
……

4. How does a composite volcano form?

……
……
……
……
……
……
……

14.7. Note the following technical words and their definitions and translate the words into Persian.

Technical words	Definitions
Volcano (noun)	vent in the earth's crust through which molten rock is ejected
Volcanic (adjective)	relate to volcanoes
Volcanism (noun)	volcanic processes and phenomena, volcanicity
Volcanology (noun)	study of volcanoes and volcanic phenomena

Volcanologist (noun)	expert in the study of volcanoes and volcanic phenomena
Volcanist (noun)	a synonym of volcanologist
Volcanically (adverb)	in a volcanic manner; explosively
Volcanogenic	formed by processes directly connected with volcanism
Volcano (noun)	vent in the earth's crust through which molten rock is ejected

Now, fill in the blanks with the appropriate words.

1. One of Jupiter's moons, Io, is ..... active.
2. Some of basaltic magma rose to the surface to cause ..... eruptions.
3. The tuffs erupted from several large ..... that were active from 16 to 6 million years ago.
4. Andesitic ..... often forms a curved chain of islands called island arc.
5. Triassic rocks are mostly sedimentary in origin, and ..... rocks do occur in relatively minor amounts.
6. ..... are common in continental rifts, including the East African rift.
7. Gold is mined from some ..... deposits.
8. Bubble separation is one of the current topics in .....
9. Several South American springs in ..... active areas are depositing borates.
10. ..... eruptions continually renew Earth’s waters and its atmosphere.
11. Our Moon and Mercury are ..... dead.
12. ..... deal with active volcanoes and igneous processes.

14.8. Match the different types of volcanic rocks and structures to their definitions.

Volcanic rocks and structures	**Definition**
1. vent	A) ……. forms when basaltic magma erupts under water.
2. cinder cone	B) A fissure eruption of basaltic magma creates a …….
3. shield volcano	C) Lava and rock fragments commonly erupt from an opening called a …….
4. stratovolcanoes	D) ……. is a bowl-like depression at the summit of the volcano.
5. pillow lava	E) Fluid basaltic magma often builds a gently sloping mountain called a …….
6. crater	F) ……. is a small volcano composed of pyroclastic fragments.

1—— 2—— 3—— 4—— 5—— 6——

UNIT 15

EARTHQUAKES

هدف کلی

محتوای اصلی این درس که تحت عنوان Earthquakes ارائه گردیده است، در خصوص آشنایی با منشأ زلزله، انواع امواج زلزله، و رابطه آن با تکتونیک صفحه‌ای می‌باشد. هدف کلی از تدوین این درس، آشنایی دانشجویان با تعدادی از واژه‌ها و اصطلاحات عمومی و واژه‌های کلیدی زمین‌شناسی و نیز کسب مهارت لازم در درک محتوای متن انگلیسی درس می‌باشد.

هدف‌های رفتاری

انتظار می‌رود دانشجو با مطالعه این فصل بتواند:

۱. معنی واژه‌های عام بخش ۱۵–۱ را با استفاده از فرهنگ لغات، مشخص نموده و مترادف و متضاد هر یک از واژه‌ها را بیاموزد.
۲. معنی واژه‌های کلیدی و تخصصی بخش ۱۵–۲را پس از جستجو در فرهنگ لغات زمین‌شناسی، آموخته و تلفظ صحیح آنها را فرا گیرد.
۳. متن اصلی درس را با دقت مطالعه نموده و درک کلی از مفهوم زلزله، امواج زلزله، واحدهای تعیین شدت زلزله و رابطه بین زلزله و تکتونیک صفحه‌ای داشته باشد.
۴. با توجه به مفهوم کلی درس، صحیح یا غلط‌بودن عبارات تمرین ۱۵–۴ را مشخص نماید.
۵. با توجه به متن درس، در بخش ۱۵–۵ مناسب‌ترین گزینه را از بین چهار گزینه، انتخاب و علامت‌گذاری نماید.
۶. پاسخ سؤالات بخش ۱۵–۶ را با توجه به مفهوم کلی درس، مشخص نموده و سعی نماید تا بدون استفاده از جمله‌بندی‌های متن درس، سؤالات را جواب دهد.
۷. اقسام کلام (اسم، فعل، قید و صفت) واژه تخصصی Seismology به همراه تعاریف آنها را آموخته و قادر به به‌کار بردن این واژه‌ها در جملات مختلف تخصصی باشد.
۸. متن انگلیسی بخش ۱۵–۸ را با واژه‌های داده شده تکمیل و سپس آن را به فارسی روان ترجمه نماید.
۹. جدول شدت دوازده‌گانه مرکالی را با استفاده از واژه‌های داده شده تکمیل نماید.

15.1. COMMON WORDS: Note the synonyms and antonyms of following words and translate the words into Persian.

Word	Synonym	Antonym
suddenly	rapidly	gradually
return	revert	depart
response	answer	question
outward	toward the outside	inward
initial	first	final
increment	increase	reduction

15.2. TECHNICAL WORDS: Note the pronunciation of the following technical words and expressions and translate them into Persian.

1. earthquake ……..
2. disaster ……..
3. seismology /sÿz-mol-ŏ-jee/ ……..
4. seismologist ……..
5. predict ……..
6. strike ……..
7. friction ……..
8. confining pressure ……..
9. stress ……..
10. frictional force ……..
11. elastic rebound theory ……..
12. predeformed shape ……..
13. seismic wave /sÿz-mik/ ……..
14. focus ……..
15. epicenter /ep-ă-sen-ter/ ……..
16. primary body wave ……..
17. compressional ……..
18. longitudinal ……..

19. secondary body wave ……..
20. P body wave ……..
21. S body wave ……..
22. surface wave ……..
23. seismometer /sÿz-mom-ĕ-ter/ ……..
24. seismograph /sÿz-mŏ-graf, -grahf/ ……..
25. seismogram /sÿz-mŏ-gram/ ……..
26. magnitude ……..
27. Richter scale /rik-ter/ ……..
28. modified Mercalli scale /mer-kah-lee/ ……..

15.3. Reading

EARTHQUAKES

What is an earthquake?

An **earthquake** is a sudden motion or shaking of the Earth caused by the sudden release of energy that is stored in rocks. Most earthquakes are associated with rock movements along **faults** below the surface of the earth. Because of **friction** and high **confining pressure**, the fault blocks don't move until the tectonic stress becomes great enough to overcome the **frictional force**.

Earthquakes may also result according to the **elastic rebound theory** (Fig. 15-1). It suggests that in some cases energy is stored in rock that is being bent (deformed) by tectonic forces. The rock breaks until the energy in the rock exceeds the bonding strengths between minerals. When the rock breaks, it suddenly returns to its predeformed shape. Then, the crust moves violently as a result of the quickly released force. This results in the formation of a new fault.

Earthquakes can be some of the worst natural disasters, taking thousands of lives and creating billions of dollars of damage. For instance, in December of 2003, the ancient Iranian city of Bam was destroyed in an earthquake. It was clear in reports that failed buildings

were the main cause of the large number of deaths. Bam earthquake started at four in the morning when most of the residents were in bed. One-third of its population of 200,000 was either killed or seriously injured. Most of the buildings, including two of the city's hospitals, were destroyed. Seismologists hope to eventually predict earthquakes before they strike.

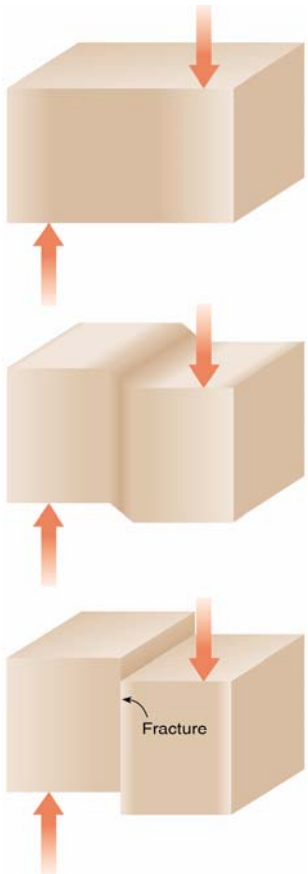


Figure 15-1. The behavior of a rock as stress increases. At first the rock deforms by elastic deformation. Beyond the elastic limit, the rock deforms plastically. Finally, the rock fractures.

Earthquake waves

When rock masses suddenly move deep within the earth in response to tectonic stress, energy in the form of **seismic waves** moves outward through the rock from the point of origin, called the **focus**. The initial

movement occurs at the focus.

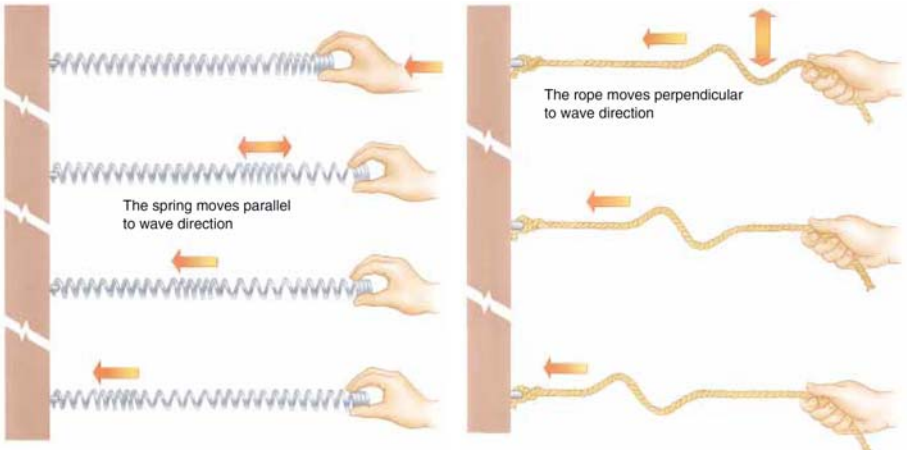
The **epicenter** is the point on the surface directly above the focus. There are three types of seismic waves: P and S body waves and surface waves.

a) Body waves: Body waves travel through the Earth's interior. Body waves radiate outward from the focus in all directions and travel through solid rock.

A **P body wave (primary body wave**) is a compressional (longitudinal) wave that causes the particles in the rock to vibrate back and forth in the same direction the wave moves (Fig. 15-2a).

An **S body wave (secondary body wave)** is only about half as fast as a P wave and causes the rock to vibrate at right angles (90 degree) to the direction of wave travel (Fig. 15-2b).

b) Surface waves: Surface waves are the slowest seismic waves and travel outward on the earth's surface from the epicenter much like ripples do from a stone thrown into water. They create most of the damage at the surface.



(a) **(b)**

Figure 15-2 (a) Model of a P wave; a compressional wave. The wave is propagated along the spring. The particles in the spring move parallel to the direction of wave propagation. **(b)** Model of an S wave; a shear wave. The wave is propagated along the rope. The particles in the rope move perpendicular to the direction of wave propagation.

Measurement of seismic waves

Seismic waves are detected with a **seismometer**. The seismometer is connected to a **seismograph.** A **seismograph** is a device that records seismic waves as a series of wavy lines called a **seismogram**.

Measurement of earthquake strength

1. **Magnitude:** In 1935 Charles Richter devised the **Richter scale** to express earthquake magnitude. Richter magnitude is calculated from the height of the largest earthquake body wave recorded on a specific type of seismograph.

   The **Richter scale** is a numerical scale that lists earthquake magnitudes in logarithmic increments from about 2 to 8.6 - the highest value ever recorded on the scale. A magnitude 6 earthquake will move the ground 10 times that of a magnitude 5 event and release 32 times the energy.

   The Richter scale is more quantitative than earlier intensity scales, but it is not a precise measure of earthquake energy.
2. **Intensity:** The strength of an earthquake can be measured as a function of intensity. The **modified Mercalli scale** classifies intensity from 1 to 12 according to the amount of resulting damage. This system is not totally accurate because the amount of damage is often proportional to the following items:

a) population in an area,
b) the type of design and construction of buildings,
c) and the base on which the buildings sit (that is, bedrock or sediment).

Earthquakes and plate tectonic

Earthquakes are common at all three types of plate boundaries. The San Andreas fault zone is an example of a transform plate boundary, where two plates slide past one another.

Subduction zone earthquakes occur when the subducting plate slips suddenly. Earthquakes occur at divergent plate boundaries as blocks of lithosphere along the fault drop downward.

Earthquakes occur in plate interiors along old faults or where sediments press down the lithosphere.

EXERCISES

15.4. According to the passage, which of the following statements are "true" or "false"? Insert "T" or "F" in the boxes at the right.

1. Mercalli scale expresses earthquake magnitude.
2. A seismogram is a device that records seismic waves.
3. P wave is a longitudinal wave.
4. P and S waves are surface waves.
5. The initial movement occurs at the focus.
6. P wave velocity is as the same as S wave.

15.5. Choose a, b, c, or d which best completes each item.

1. How subduction zone earthquakes occur?
   a) When the blocks of lithosphere along the fault drop downward.
   b) When the subducting plate slips suddenly.
   c) When sediments press down the lithosphere.
   d) When two plates slide past one another.
2. Which instrument detects the seismic waves?
   a) seismograph b) seismometer
   c) seismogram d) seismologist
3. The strength of an earthquake is related to ……..
   a) intensity b) plate tectonic

c) Mercalli scale d) Richter scale

4. What happens beyond the elastic limit?
   a) the rock returns to its pre deformed shape.
   b) plate slips suddenly.
   c) the rock fractures.
   d) the rock deforms plastically.

15.6. Write the answers to the following questions in your own words.

1. Define focus and epicenter.

……
……
……
……
……
……
……

2. Describe the behavior of rock during elastic deformation, plastic deformation, and brittle fracture.

……
……
……
……
……
……
……

3. Discuss the differences between P waves, S waves, and surface waves.

……
……
……
……
……

……
……

15.7. Note the following technical words and their definitions and translate the words into Persian.

Technical words	Definitions
Seismic (adjective)	pertaining to an earthquake, caused by an earthquake
Seismicity (noun)	frequency and geographical distribution of earthquakes
Seismology (noun)	study of earthquakes and the nature of the Earth's interior based on evidence from seismic waves.
Seismologist (noun)	one who studies earthquakes and related phenomena
Seismologic	
Seismological (adjective)	pertaining to the study of earthquakes and related phenomena
Seismogram (noun)	visual record of earthquakes and seismic activity
Seismograph (noun)	instrument for measuring and recording vibrations of earthquakes
Seismometer (noun)	seismograph which measures ground movement caused by earthquakes
Seismically (adverb)	in a seismic manner; with regard to earthquakes
Seismogenic	

Now, fill in the blanks with the appropriate words.

1. Antarctica has low ..... and few active volcanoes.
2. Iran is a highly ..... country where numerous earthquakes occur.
3. There is some ..... evidence for lithospheric slabs

descend into the mantle in subduction zones.

4. The measurement of seismic waves is fundamental to .....
5. ..... specifically designed for measuring the strong ground motion near the source of an earthquake are called accelerographs.
6. Surface flows of groundwater occurred along fault lines in desert areas of Iran during earthquakes in 1903, 1923, and 1930, has been known to .....
7. Where an active fault has not been identified, a probable location is selected by ..... for each ..... zone.
8. A century ago, instrumental ..... began to reveal the internal structure of Earth.
9. San Andreas Fault system is the location of present-day .....
10. After Bam earthquake of 26 December 2003, ... aspects of Bam fault have been studied by many .....
11. Synthetic ..... are computed for various focal depths.
12. The Earth's crust is characterized by an upper ..... active zone.
13. The arrival times of ..... waves at ..... at different sites are first used to find the location of an earthquake.

15.8. Fill in the blanks with the following words and translate the passage into Persian.

"movements", "severe", "strength", "plates", "rock", "waves".

A sudden violent movement of the Earth's surface. Many earthquakes are relatively gentle, but the ……**1**……. ones that cause great damage are caused by ……**2**……. of the Earth's crust.

Geologists have discovered that under the continents and oceans the Earth's crust is made up of a number of sheets of ……**3**…….

called ……**4**……. which can rub against each other or pull apart, creating the shock waves that form the earthquake.

The ……**5**……. of the ……**6**……. is measured on the Richter Scale and severe earthquakes where registered between 7 and 9 on the scale.

.....
.....
.....
.....
.....
.....
.....
.....
.....
.....

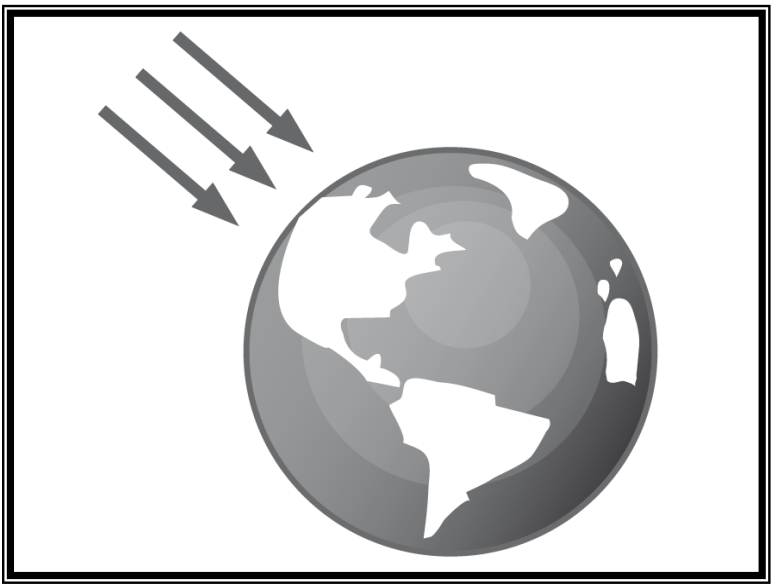
15.9. Fill in the 12 steps of Mercalli scale using following words. You can modify with the adverbs "very" or "slightly".
"damaging", "destructive", "devastating", "observed", "strong", "weak".

A simplified intensity scale (here based on the European Macroseismic Scale)

1. Not felt - detected by seismic instruments only
2. _____ - felt by very few people
3. _____ - felt by a few people indoors
4. _____ - noticed by many people, windows and doors rattle
5. _____ - some small objects fall over
6. _____ - cracks to plaster, objects fall off shelves
7. _____ - parts of chimneys fall
8. _____ - large cracks in walls
9. _____ - some houses collapse
10. _____ - many houses collapse
11. _____ - most buildings destroyed
12. Catastrophic - everything destroyed

UNIT 16

GLOBAL WARMING AND CLIMATE CHANGE



هدف کلی

محتوای اصلی این درس که تحت عنوان Global warming and climate change ارائه گردیده است، در خصوص علل پدیده گرم‌شدن زمین و تغییرات آب‌وهوایی ناشی از این عامل بحث می‌کند. هدف کلی از تدوین این درس، آشنایی دانشجویان با تعدادی از واژه‌ها و اصطلاحات عمومی و واژه‌های کلیدی زمین‌شناسی و نیز کسب مهارت لازم در درک محتوای متن انگلیسی درس می‌باشد.

هدف‌های رفتاری

انتظار می‌رود دانشجو با مطالعه این فصل بتواند:

۱. معنی واژه‌های عام بخش ۱۶–۱ را با استفاده از فرهنگ لغات، مشخص نموده و مترادف و متضاد هر یک از واژه‌ها را بیاموزد.

۲. معنی واژه‌های کلیدی و تخصصی بخش ۱۶–۲ را پس از جستجو در فرهنگ لغات زمین‌شناسی، آموخته و تلفظ صحیح آنها را فرا گیرد.

۳. متن اصلی درس را با دقت مطالعه نموده و درک کلی از مفهوم گرم‌شدن کره زمین، علل ایجاد این پدیده، اثر گلخانه‌ای و اهمیت آن داشته باشد.

۴. با توجه به مفهوم کلی درس، صحیح یا غلط‌بودن عبارات تمرین ۱۶–۴ را مشخص نماید.

۵– با توجه به متن درس، در بخش ۱۶–۵ مناسب‌ترین گزینه را از بین چهار گزینه، انتخاب و علامت‌گذاری نماید.

۶. متن انگلیسی بخش ۱۶–۶ را با واژه‌های داده‌شده تکمیل و سپس آن را به فارسی روان ترجمه نماید.

۷. جملات پراکنده دو ستون جدول بخش ۱۶–۷ را تکمیل نماید.

۸. نتایج گرم‌شدن زمین را در مکان‌های خالی نمودار بخش ۱۶–۸ وارد نماید.

16.1. COMMON WORDS: Note the synonyms and antonyms of following words and translate the words into Persian.

Word	Synonym	Antonym
clear	obvious	vague
release	liberate	imprison
enhance	increase	diminish
rise	move upward	move downward
constant	unchanging factor	variable
intense	powerful	mild

16.2. TECHNICAL WORDS: Note the pronunciation of the following technical words and expressions and translate them into Persian.

1. climate ……..
2. greenhouse gases ……..
3. absorb ……..
4. radiate ……..
5. global warming ……..
6. emission ……..
7. El Niño /el neenyoh/ ……..
8. ice sheets ……..
9. glacier /glay-sher/ ……..

16.3. Reading

GLOBAL WARMING AND CLIMATE CHANGE

What is global warming?

Global warming is the increase in the average temperature of the Earth's near-surface air and oceans since the mid-20th century and its projected continuation. **Climate** has always changes from natural causes, but it is becoming clear that human activities have caused

most of the past century's **warming** by releasing heat trapping gases – called **greenhouse gases** – into the atmosphere.

The greenhouse effect

The "greenhouse effect" is the warming that happens when certain gases in Earth's atmosphere trap heat. These gases let in light but keep heat from escaping, like the glass walls of a greenhouse (Fig. 16-1).

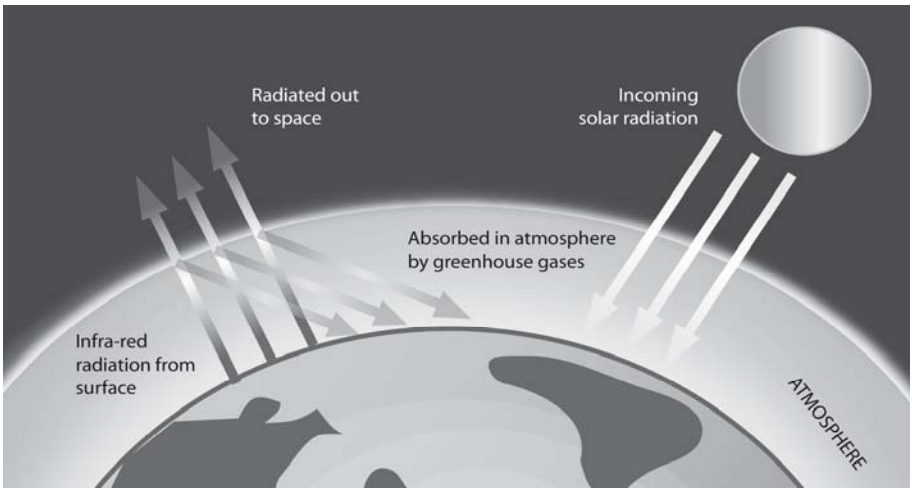


Figure 16-1. The greenhouse effect.

First, sunlight shines onto the Earth's surface, where it is absorbed and then radiates back into the atmosphere as heat. In the atmosphere, "greenhouse" gases trap some of this heat, and the rest escapes into space. The more greenhouse gases are in the atmosphere, the more heat gets trapped.

Scientists have known about the greenhouse effect since 1824, when Joseph Fourier calculated that the Earth would be much colder if it had no atmosphere. This greenhouse effect is what keeps the Earth's climate livable. Without it, the Earth's surface would be an average of about 60 degrees Fahrenheit cooler. In 1895, the Swedish chemist Svante Arrhenius discovered that humans could enhance the greenhouse effect by making carbon dioxide, a greenhouse gas. He began 100 years of climate research that has given us a complex

understanding of global warming.

Levels of greenhouse gases (GHGs) have gone up and down over the Earth's history, but they have been fairly constant for the past few thousand years. Global average temperatures have stayed fairly constant over that time as well, until recently. Through the burning of fossil fuels, humans are enhancing the greenhouse effect and warming Earth.

Global warming and climate change

Scientists often use the term "climate change" instead of global warming. This is because as the Earth's average temperature climbs, winds and ocean currents move heat around the globe in ways that can cool some areas, warm others, and change the amount of rain and snow falling. As a result, the climate changes differently in different areas.

Aren't temperature changes natural?

The average global temperature and concentrations of carbon dioxide (one of the major greenhouse gases) have changed on a cycle of hundreds of thousands of years as the Earth's position relative to the sun has varied. As a result, ice ages have come and gone.

However, for thousands of years now, emissions of GHGs to the atmosphere have been balanced out by GHGs that are naturally absorbed.

As a result, GHG concentrations and temperature have been fairly stable. This stability has allowed human civilization to develop within a consistent climate.

Occasionally, other factors briefly influence global temperatures. Volcanic eruptions, for example emit particles that temporarily cool the Earth's surface. But these have no lasting effect beyond few years. Other cycles, such as **El Niño**, also work on fairly short and predictable cycles (Fig. 16-2).

Now, humans have increased the amount of carbon dioxide in the atmosphere by more than a third since the industrial revolution. Changes this large have historically taken thousands of years but are now happening over the course of decades.

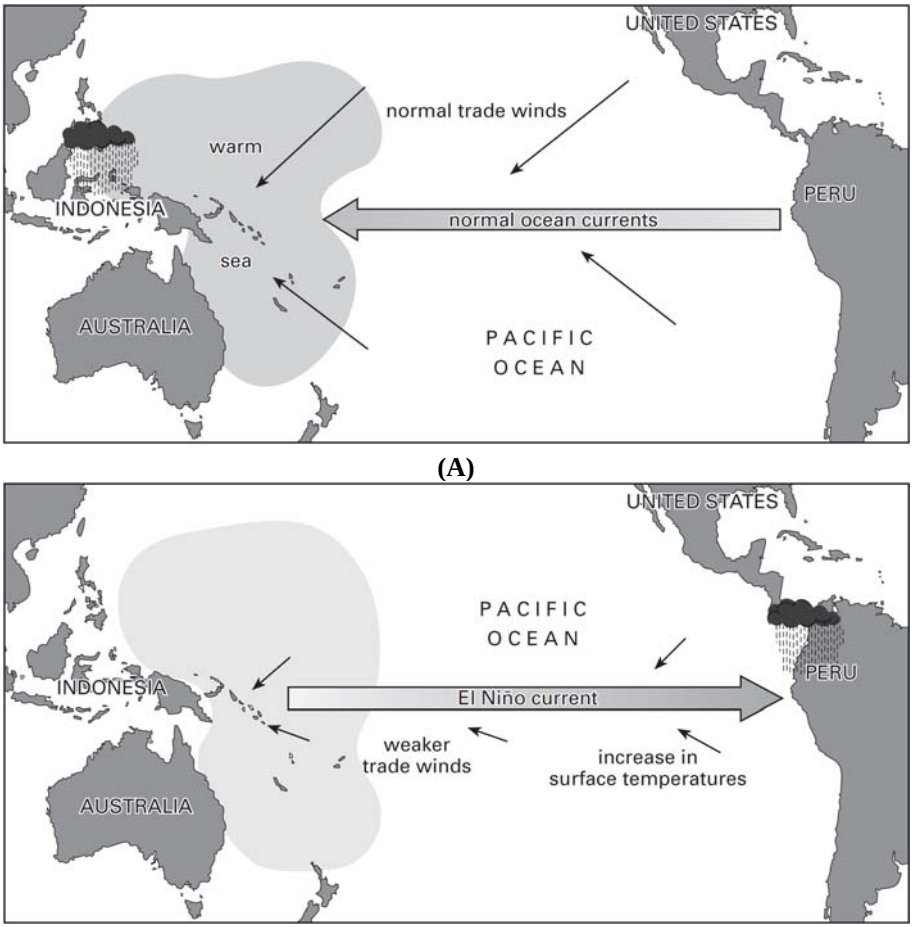


Figure 16-2. The El Niño effect. **(A)** Under normal conditions the trade winds push water from east to west and warm water accumulates around Indonesia. **(B)** In El Niño years, the trade winds weaken and the warm water flows back toward the coast of Latin America.

Why is this a concern?

The rapid rise in greenhouse gases is a problem because it is changing the climate faster than some living things may be able to adapt. Also, a new and more unpredictable climate poses unique challenges to all life.

Historically, Earth's climate has regularly shifted back and forth between temperatures like those we see today and temperatures cold enough that large sheets of ice covered much of North America and Europe. The difference between average global temperatures today

and during those ice ages is only about 5 degrees Celsius (9 degrees Fahrenheit), and these swings happen slowly, over hundreds of thousands of years. Now, with concentrations of greenhouse gases rising, Earth's remaining ice sheets (such as Greenland and Antarctica) are starting to melt too. The extra water could potentially raise sea levels significantly.

When sea levels rises, weather can become more extreme. This means more intense major storms, more rain followed by longer and drier droughts (a challenge for growing crops), changes in the ranges in which plants and animals can live, and loss of water supplies that have historically come from glaciers.

Scientists are already seeing some of these changes occurring more quickly than they had expected. According to the studies, eleven of the twelve hottest years since thermometer readings became available occurred between 1995 and 2006.

EXERCISES

16.4. According to the passage, which of the following statements are "true" or "false"? Insert "T" or "F" in the boxes at the right.

1. Arrhenius discovered that the Earth would be much colder if it had no atmosphere.

2. Greenhouse effect is useful for the earth.

3. Levels of greenhouse gases have been fairly constant for the past few thousand years.

4. Volcanic eruptions have lasting effect beyond several years.

5. El Niño effect influences the global temperatures.

16.5. Choose a, b, c, or d which best completes each item.

1. Sunshine radiates back into the atmosphere as:
   a) atmosphere b) heat
   c) gas d) greenhouse
2. What happens with rising of greenhouse gases?
   a) ice sheets melt b) loss of water supplies
   c) swings happen slowly d) the climate can change
3. which of the following answers are related to sea levels rising?
   a) longer and drier droughts b) more storms
   c) more rains d) all answers
4. Since the industrial revolution, the amounts of carbon dioxide in the atmosphere have increased ……..
   a) two times b) three times
   c) constantly d) 33 percent

16.6. Fill in the blanks with the following words and translate the passage into Persian.

"atmosphere", "greenhouse gases", "infrared radiation", "ozone", "solar radiation", "surface", "temperature", "water vapour".

The Earth has a natural …….**1**……. control system. Certain atmospheric gases are critical to this system and are known as …….**2**……. On average, about one third of the …….**3**……. that hits the earth is reflected back to space. Of the remainder, some is absorbed by the …….**4**……. but most is absorbed by the land and oceans. The Earth's …….**5**……. becomes warm and as a result emits …….**6**…….

The greenhouse gases trap the infrared radiation, thus warming the atmosphere. Naturally occurring greenhouse gases include …….**7**……., carbon dioxide, …….**8**……., methane and nitrous oxide, and together create a natural greenhouse effect.

However, human activities are causing greenhouse gas levels in the atmosphere to increase.

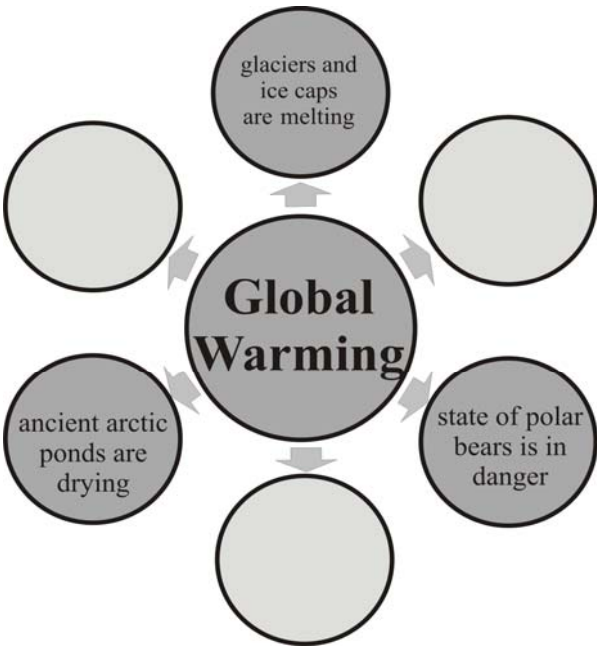
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....

16.7. Match the sentence parts which are about the results of global warming.

1. Researchers have evidence that	A) have broken off in the past decade.
2. Scientists say the rise in sea levels around the world caused by the melting of ice	B) global warming is melting the ice in Antarctica faster than had previously been thought.
3. Over the past years, scientists have found that melting Antarctic ice caps contribute	C) should not be under-estimated.
4. Several major sections of Antarctic ice	D) at least 15% to the current global sea level rise of 2 mm a year.

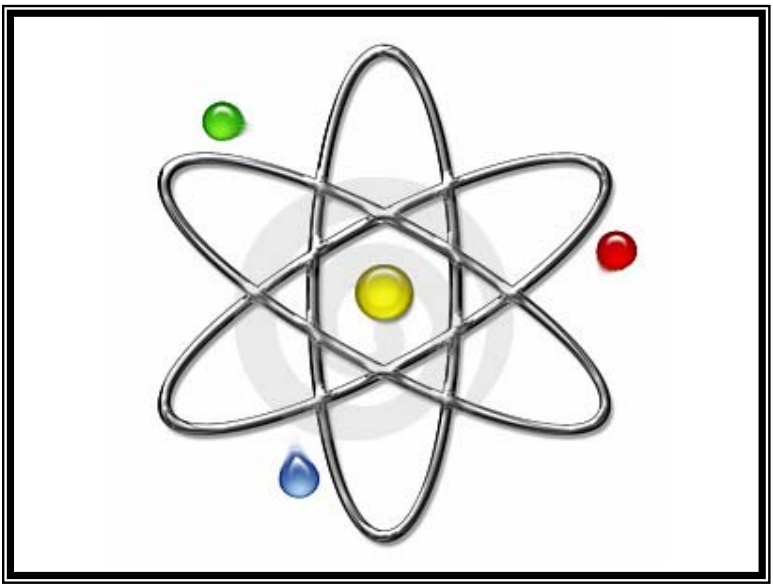
1—— 2—— 3—— 4——

16.8. Complete the following diagram.



UNIT 17

NUCLEAR FUELS AND REACTORS



هدف کلی

محتوای اصلی این درس که تحت عنوان Nuclear fuels and reactors ارائه گردیده است، در خصوص آشنایی با سوخت‌های هسته‌ای، صنعت انرژی هسته و نحوه کارکرد نیروگاه‌های هسته‌ای می‌باشد. هدف کلی از تدوین این درس، آشنایی دانشجویان با تعدادی از واژه‌ها و اصطلاحات عمومی و واژه‌های کلیدی زمین‌شناسی و نیز کسب مهارت لازم در درک محتوای متن انگلیسی درس می‌باشد.

هدف‌های رفتاری

انتظار می‌رود دانشجو با مطالعه این فصل بتواند:

۱. معنی واژه‌های عام بخش ۱۷–۱ را با استفاده از فرهنگ لغات، مشخص نموده و مترادف و متضاد هر یک از واژه‌ها را بیاموزد.

۲. معنی واژه‌های کلیدی و تخصصی بخش ۱۷–۲ را پس از جستجو در فرهنگ لغات زمین‌شناسی، آموخته و تلفظ صحیح آنها را فرا گیرد.

۳. متن اصلی درس را با دقت مطالعه نموده و درک کلی از مفهوم سوخت‌های هسته‌ای، رآکتورهای هسته‌ای و نحوه کارکرد آنها و نیز اهمیت استفاده از صنعت انرژی هسته‌ای داشته باشد.

۴. با توجه به مفهوم کلی درس، صحیح یا غلط‌بودن عبارات تمرین ۱۷–۴ را مشخص نماید.

۵. با توجه به متن درس، در بخش ۱۷–۵ مناسب‌ترین گزینه را از بین چهار گزینه، انتخاب و علامت‌گذاری نماید.

17.1. COMMON WORDS: Note the synonyms and antonyms of following words and translate the words into Persian.

Word	Synonym	Antonym
modern	new and up-to-date fashion	old-fashioned
split	separate	join
trigger	start	finish
compress	compact	expand
discard	throw away	keep
recent	of late time	old
costly	expensive	cheap
halt	stop	start
decline	decrease	increase
tremendous	huge	small

17.2. TECHNICAL WORDS: Note the pronunciation of the following technical terms and expressions and translate them into Persian.

1. nuclear fission ……..
2. isotope /ÿ-sŏ-tohp/ ……..
3. nuclei ……..
4. branching chain reaction ……..
5. bombardment ……..
6. radioactivity ……..
7. reactor ……..
8. fuel rod ……..
9. control rods ……..
10. power plant ……..
11. neutron-absorbing alloys ……..
12. mining ……..
13. radioactive wastes ……..
14. processing ……..

17.3. Reading

NUCLEAR FUELS AND REACTORS

What are nuclear fuels?

Nuclear fuel is any material that can be consumed to derive nuclear energy, by analogy to chemical fuel that is burned to derive energy. A modern nuclear power plant uses **nuclear fission** to produce heat and generate electricity (Fig. 17-1). One isotope of uranium, U-235, is the major fuel. When a U-235 nucleus is bombarded with a neutron, it breaks apart (the word *fission* means "splitting"). The initial reaction releases two or three neutrons. Each of these neutrons can trigger the fission of additional nuclei; hence, this type of nuclear reaction is called a **branching chain reaction**. Because this fission is initiated by neutron bombardment, it is not a spontaneous process and is different from natural radioactivity.

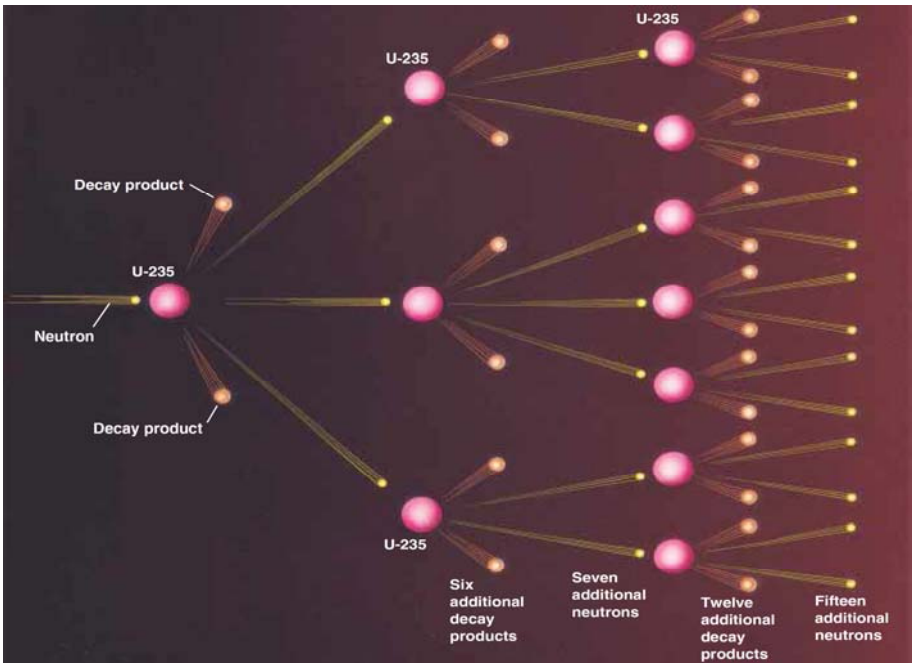


Figure 17-1. When a neutron strikes a uranium-235 nucleus, the nucleus splits into two roughly equal fragments and emits two or three neutrons. These neutrons can then initiate additional reactions, which produce more neutrons. A branching chain reaction accelerates rapidly through a sample of concentrated uranium-235.

To fuel a nuclear reactor, concentrated uranium is compressed into small pellets. Each pellet could easily fit into your hand but contains the energy equivalent of 1 ton of coal. A column of pellets is encased in a 2-meter-long pipe called a **fuel rod** (Fig. 17-2). A typical nuclear power plant contains about 50,000 fuel rods bundled into assemblies of 200 rods each. **Control rods** made of neutron-absorbing alloys are spaced among the fuel rods. The control rods fine-tune the reactor. If the reaction speeds up because too many neutrons are striking other uranium atoms, then the power plant operator lowers the control rods to absorb more neutrons and slow down the reaction. If fission slows down because too many neutrons are absorbed, the operator raises the control rods. If an accident occurs and all internal power systems fail, the control rods fall into the reactor core and quench the fission.

a) **b)**

Figure 17-2. (a) Fuel pellets containing enriched uranium-235. Each pellet contains the energy equivalent of 1 ton of coal. **(b)** Fuel pellets are encased into narrow rods that are bundled together and lowered into the reactor core.

The reactor core produces tremendous amounts of heat. A fluid, usually water, is pumped through the reactor core to cool it. The cooling water (which is now radioactive from exposure to the core) is then passed through a radiator, where it heats another source of water to produce steam. The steam drives a turbine, which in turn generates electricity (Fig. 17-3).

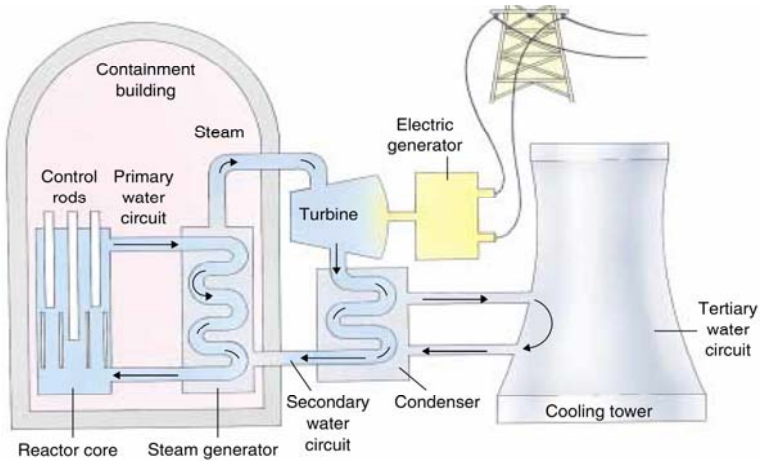


Figure 17-3. In a nuclear power plant, fission energy creates heat, which is used to produce steam. The steam drives a turbine, which generates electricity.

The nuclear power industry

Every step in the mining, processing and use of nuclear fuel produces radioactive wastes. The mine waste discarded during mining is radioactive. Enrichment of the ore produces additional radioactive waste. When a U-235 nucleus undergoes fission in a reactor, it splits into two useless radioactive nuclei that must be discarded.

Finally, after several months in a reactor, the U-235 concentration in the fuel rods drops until the fuel pellets are no longer useful. In some countries, these pellets are reprocessed to recover U-235, but in the United States this process is not economical and the pellets are discarded.

In recent years, construction of new reactors has become so costly that electricity generated by nuclear power is more expensive than that generated by coal-fired power plants. Public concern about accidents and radioactive waste disposal has become acute. The demand for electricity has risen less than expected during the past two decades. As a result, growth of the nuclear power industry has halted. After 1974, many planned nuclear power plants were canceled, and after 1981, no new orders were placed for nuclear power plants in the United States.

In 1994, 109 commercial reactors were operating in the United States.

These generators produced 22 percent of the total electricity consumed that year. Those numbers will decline in the coming decade because no new plants have been started and old plants must be decommissioned.

EXERCISES

17.4. According to the passage, which of the following statements are "true" or "false"? Insert "T" or "F" in the boxes at the right.

1. Electricity is produced by branching chain reaction.
2. Electricity generated by coal-fired power plants is more expensive than that generated by nuclear power.
3. By fission in a reactor, U-235 nucleus splits into two useful radioactive nuclei.
4. Neutron-absorbing alloys are used in control rods.
5. The energy of each fuel pellet is equal to energy of 1 ton of coal.

17.5. Choose a, b, c, or d which best completes each item.

1. What is used for cooling of a reactor?
   a) water b) steam
   c) fuel rod d) coal
2. What is created by fission energy in a nuclear power plant?
   a) Heat b) Steam
   c) Electricity d) Fuel rod
3. Which of the following items are used for bombardment of U-235?
   a) fuel rod b) neutron
   c) control rod d) fission energy

THE ANSWER KEYS

Unit 1

1.4

1. T	2. F	3. F	4. T
5. F	6. T		

1.5

1. c	2. b	3. a	4. a

1.7

1. Geologists	2. geologic	3. geology	4. geologically
5. geological	6. geologically		

1.8

1. soils	2. Earthquakes	3. crustal	4. volcanic
5. processes	6. erosion		

1.9

1. A rock is a solid material that is composed of various minerals.
2. The upper part of the mantle consists of lithosphere and asthenosphere.
3. Outer core, is believed to be a layer of molten liquid rich in nickel and iron

1.11

Geological branches	Definition	Example
Petrology	Dealing with the origin, occurrence structure, and history of rocks.	Igneous rocks, metamorphic rocks
Economic geology	The application of geologic knowledge to the search for the understanding of mineral deposits.	nonmetallic minerals, coal, mineral resources

Geochemistry	The study of the distribution of the chemical elements in minerals, ores, rocks, soils, water and the atmosphere.	Rock analysis
Structural geology	Deals with the form, arrangement and internal structure of the rocks.	Folds, faults
Stratigraphy	Deals with the original succession and age relations of rock strata.	Sandstone, sedimentary rocks
Tectonics	Dealing with the broad architecture of the outer part of the earth.	Mountain building, subduction

Unit 2

2.4

1. F 2. F 3. T 4. F
5. F 6. T

2.5

1. b 2. c 3. a 4. d
5. a 6. b 7. d

2.7

1. sedimentary 2. sediments 3. Sedimentation 4. sedimentological
5. sedimentology 6. Sedimentologists

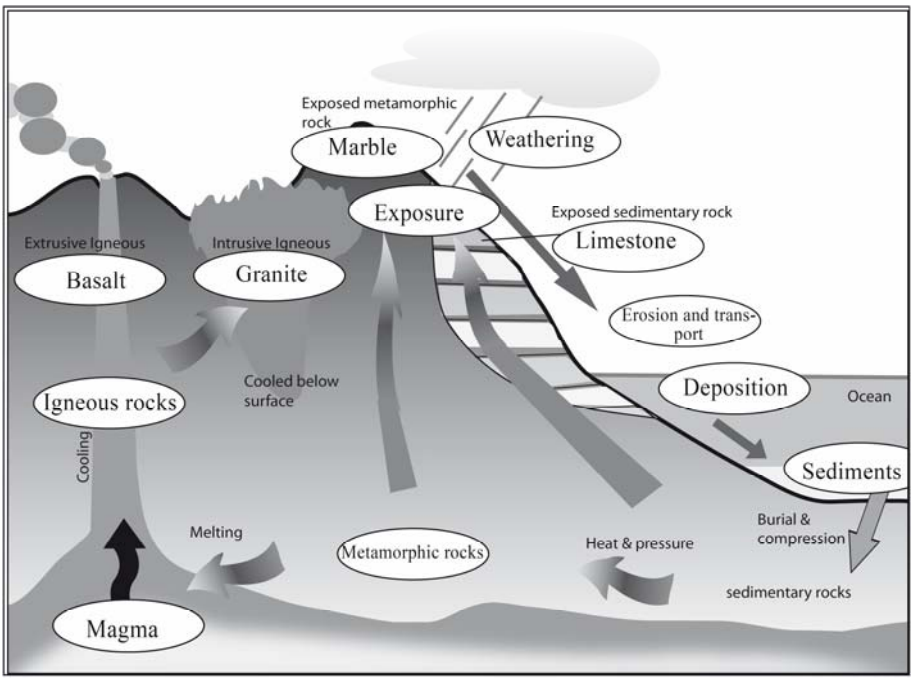
2.8

1. molten 2. loose 3. solid 4. mountain
5. silicate 6. volcanic 7. surface 8. textures
9. porphyry 10. fine-grained

2.9

1. D 2. E 3. F 4. B
5. C 6. A

2.10



2.11

Types	Definition	Example
Sedimentary rocks	These rocks were formed from the remains of animals or plants and other rocks which had been crushed together.	Limestone, coal, sandstone, shale
Igneous rocks	These rocks were formed when hot, molten volcanic material cooled and solidified.	Granite, basalt, lava
Metamorphic rocks	These rocks were once igneous or sedimentary and were changed by great heat and pressure.	Marble, slate

Unit 3

3.4

1. T 2. F 3. F 4. T
5. F 6. F

3.5

1. a	2. a	3. a	4. d
5. c	6. b		

3.7

1. correlative	2. correlatable	3. correlation	4. correlations
5. correlatable	6. correlating	7. correlate	

3.8

1. Key bed is used for time correlation.
2. Unconformity shows a gap in deposition.
3. Most Proterozoic organisms had no hard parts and were single celled.
4. Geologic column is a record of rocks formed during the history of the Earth.

Unit 4

4.4

1. F	2. T	3. T	4. F

4.5

1. d	2. a	3. a	4. b

4.7

1. hydrogeological	2. Hydrogeology	3. hydrogeologists	4. hydrogeologic
5. Hydrogeologists	6. hydrogeologic	7. Hydrogeological, hydrogeologists	

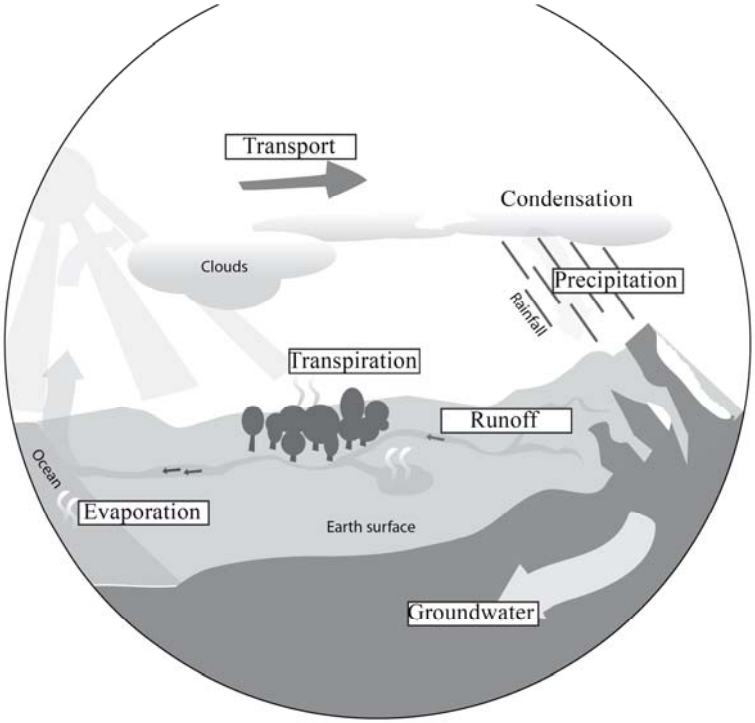
4.8

1. evaporation	2. condenses	3. transported	4. precipitation
5. groundwater	6. transportation	7. runoff	

4.9

1. B	2. F	3. G	4. D
5. A	6. C	7. E	

4.10



4.11

1. The amount of water remains constant (on earth).
2. Heat from the sun causes water to evaporate from oceans.
3. Condensation produces clouds of tiny droplets of water.

Unit 5

5.4

1. F	2. T	3. T	4. F
5. T	6. F	7. F	8. F

5.5

1. b	2. b	3. d	4. c
5. a			

5.7

1. Mineralized	2. minerals	3. mineralogical	4. mineralogy
5. mineralogically	6. Mineralogically	7. mineralization	8. mineralogic
9. mineralogical	10. mineralogist, mineral		

5.8

1. luster	2. hardness	3. colorless	4. cleavage
5. crystal form	6. pyramid	7. grains	8. glass

5.9

1. Fracture	2. Hardness	3. Luster	4. Transparency
5. Color	6. Crystal form	7. Cleavage	8. Streak
9. Density	10. Magnetism		

Unit 6

6.4

1. T	2. F	3. F	4. T
5. T	6. F	7. F	

6.5

1. b	2. c	3. a	4. c
5. b	6. c		

6.7

1. crystalline	2. crystal	3. crystalline	4. crystallographic
5. crystallography	6. crystallization	7. crystal, crystallize	

6.8

1. Color	2. colorless	3. waxy	4. translucent
5. Crystal system	6. Crystal habits	7. conchoidal	8. dispersion
9. hardness			

6.9

Group	Silicate	Oxides	Sulfides	Carbonates	Sulfates	Phosphates
	Quartz	Magnetite	Galena	Dolomite	Gypsum	Apatite
	Clays	Hematite	Pyrite	Calcite	Anhydrite	
	Feldspar	Rutile		Aragonite		

Unit 7

7.4

1. F 2. T 3. F 4. F
5. F 6. T

7.5

1. d 2. b 3. a 4. a
5. a

7.7

1. magmatism 2. magma 3. magmatic 4. magmatic
5. magma 6. magmatism 7. magmatically

7.8

1. H 2. D 3. C 4. B
5. E 6. I 7. F 8. A
9. G

Unit 8

8.4

1. F 2. T 3. T 4. F
5. F 6. T

8.5

1. c 2. a 3. b 4. d
5. d

8.7

1. depositional	2. deposit	3. deposition	4. deposition
5. depositionally	6. depositional	7. depositional	

8.8

1. C	2. D	3. F	4. E
5. A	6. G	7. B	

Unit 9

9.4

1. F	2. F	3. T	4. F
5. F	6. T	7. T	

9.5

1. b	2. c	3. a	4. b
5. c			

9.7

1. metamorphic	2. metamorphosed	3. metamorphism	4. metamorphosed
5. metamorphism, metamorphic		6. metamorphism, metamorphite	
7. metamorphically			

9.8

1. forces	2. collision	3. faulting	4. deform
5. magmas	6. pressures	7. metamorphism	

9.9

1. C	2. D	3. F	4. E
5. B	6. A		

Unit 10

10.4

1. F	2. T	3. T	4. F
5. F	6. F		

10.5

1. d	2. c	3. b	4. a
5. d			

10.7

1. erodible	2. erosion	3. erosional	4. erodibility
5. erosive	6. erode	7. erodible	8. erosive
9. erosion	10. eroding	11. erode	12. Erosional

10.8.

1. climates	2. iron	3. organic acids	4. leaching
5. evaporation	6. soil	7. weathering	8. laterite

Unit 11

11.4

1. F	2. F	3. T	4. F
5. T	6. F		

11.5

1. c	2. b	3. a	4. b
5. c			

11.7

1. tectonic	2. tectonically	3. tectonite	4. tectonics
5. tectonism	6. tectonically		

11.8

1. lithosphere	2. mantle	3. crust	4. oceanic
5. continent	6. hard	7. plastic	8. ice
9. volcanoes	10. interior		

11.9

1. C	2. A	3. E	4. B
5. D			

Unit 12

12.4

1. F	2. T	3. F	4. T
5. F	6. T		

12.5

1. b	2. d	3. c	4. b
5. a			

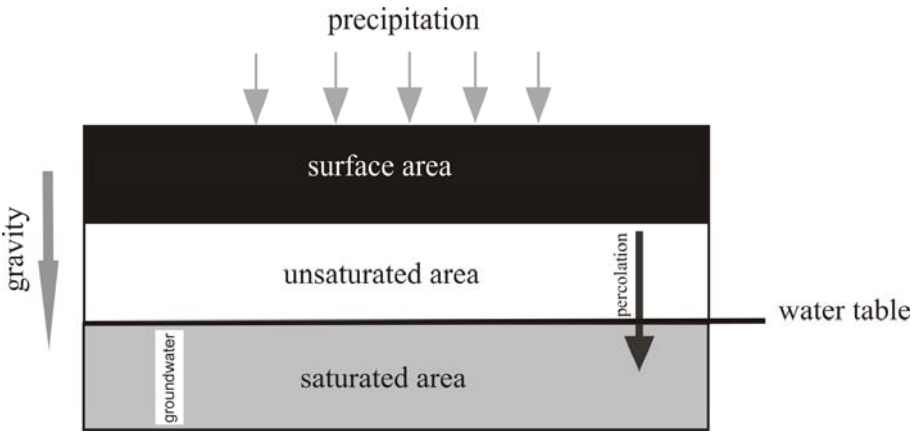
12.7

1. explosively	2. explosive	3. explosion	4. explosively
5. explosive	6. explodes	7. exploding	

12.8

1. Karst topography is an irregular land surface dotted with numerous sinkholes and depressions.
2. Aquifer is porous, permeable, saturated formations of rock that transmit groundwater easily.
3. Permeability is the ease with which fluid is transmitted through a rock's pore space.
4. Porosity is the percentage of a rock that consists of voids.

12.9



Unit 13

13.4

1. F	2. F	3. T	4. F

13.5

1. b	2. d	3. d	4. a

13.6

1. ocean	2. earthquakes	3. volcanic	4. underwater
5. epicenter	6. lithospheric	7. subduction zone	

13.7

1. C	2. F	3. A	4. E
5. D	6.B		

Unit 14

14.4

1. F	2. T	3. F	4. F
5. F			

14.5

1. b	2. b	3. c	4. c
5. d			

14.7

1. volcanically	2. volcanic	3. volcanoes	4. volcanism
5. volcanic	6. Volcanoes	7. volcanogenic	8. volcanology
9. volcanically	10. Volcanic	11. volcanically	12. Volcanologists

14.8

1. B	2. F	3. E	4. C
5. A	6.D		

Unit 15

15.4

1. F	2. F	3. T	4. F
5. T	6.F		

15.5

1. b	2. b	3. a	4. d

15.7

1. seismicity	2. seismic	3. seismological	4. seismology
5. seismographs	6. seismologists	7. seismologists, seismogenic	
8. seismology	9. seismicity	10. seismologic, seismologists	
11. seismograms	12. seismically	13. seismic, seismometers	

15.8

1. severe	2. movements	3. rocks	4. plates
5. strength	6. waves		

15.9

1. not felt	2. very weak	3. weak	4. observed
5. strong	6. slightly damaging	7. damaging	8. very damaging
9. destructive	10. very destructive	11. devastating	12. catastrophic

Unit 16

16.4

1. F	2. T	3. T	4. F
5. T			

16.5

1. b	2. a	3. d	4. d

16.6

1. temperature	2. greenhouse gases	3. solar radiation	4. atmosphere
5. surface	6. infrared radiation	7. water vapour	8. ozone

16.7

1. B 2. C 3. D 4. A

16.8

Unit 17

17.4

1. F 2. F 3. F 4. T
5. T

17.5

1. a 2. a 3. b

References

۱. سبزه‌ئی، مسیب، ۱۳۶۵، *واژه‌نامه زمین‌شناسی و علوم و فنون وابسته*. انتشارات جهاد دانشگاهی دانشگاه شهید باهنر کرمان، ۲۵۱ ص.

۲. مر، فرید، ۱۳۸۴، *واژه‌نامه جامع علوم زمین*. انتشارات کوشامهر شیراز، ۸۹۵ ص.

۳. ملکیان، فریدون، ۱۳۶۵، *فرهنگ زمین‌شناسی و علوم وابسته*. انتشارات شرکت ملی نفت ایران، ۲۸۰ ص.

4. Adams, S. & Lambert, D., (2006). *Earth Science, An Illustrated Guide to Science*. Chelsea House Pub., 208p.
5. Bates, R. L. & Jackson, J. A., (1980). *Glossary of geology*. McGraw-Hill Pub., 751p.
6. Crawford, M. J., (1998). *Physical geology*. Cliffs notes Pub., 242p.
7. David Harding, Moira Johnston (Editorial directors), (2006). *The Facts On File Earth Science Handbook*, Revised Edition, Facts On File, Inc., 272p.
8. Elizabeth Geller, (Managing Editor), (2003). *McGraw-Hill Dictionary of Earth Science*, Second Edition, McGraw-Hill Pub., 468p.
9. Jäger, B. M., (2008). *Technical English for Geosciences*. Springer-Verlag Berlin Heidelberg Pub., 209p.
10. Joseph M. Patwell (Edt), (1991). *American Heritage Dictionary of the English Language*, Third Edition, Jonathan P. Latimer Pub., 8652p.
11. Ludman, A. & Coch, N. K. (1982). *Physical geology*. McGraw-Hill Pub., 587p.
12. Parker. S. P., (1988). *McGraw-Hill encyclopedia of the geological sciences*, Second edition. McGraw-Hill Pub., 722p.
13. Plummer, Ch. C. and McGeary, D., (1991). *Physical geology*. WCB Pub., 543p.
14. Selley, R. C., Cocks, L. R. M. & Plimer, I. R. (2005). *Encyclopedia of geology*. 5 volumes, Elsevier Ltd. Pub., 3345p.
15. Smith, K. & D. N., Petley, (2009). *Environmental Hazards: Assessing Risk & Reducing Disaster*. Routledge Pub., 5 edition, 416 p.
16. Thompson, G. R. & Turk, J., (1997). *An introduction to physical geology*. Brooks Cole Pub., 2 edition, 432p.