DOWNLOAD PDF SEDIMENTARY GEOLOGY AN INTRODUCTION TO SEDIMENTARY ROCKS AND STRATIGRAPHY

Chapter 1 : GEOL - Sedimentation and Stratigraphy

The two primary areas of study - sedimentary rocks and stratigraphy - are presented in this sleek, complete and up-to-date undergraduate text. Background principles in chemistry, physics and structure are introduced as needed, so that the authors' lean, lively approach and focus on soft rock geology principles are preserved.

The process that turns bedrock into sediment or soil is called weathering. Weathering is achieved by both mechanical and chemical means. Gravity and associated processes of mass wasting see chapter 10 move the mechanical sediment to locations where it can be lithified into detrital sedimentary rock. Below are ways that bedrock is weathered mechanically. Pressure Expansion The outer layer of this granite is fractured and eroding away, known as exfoliation Think about the rock cycle studied in chapter 1. Bedrock that is buried to some depth within the Earth is under high pressure and temperature. As this rock is brought to the surface by uplift and erosion, the temperature changes slowly, while the pressure changes immediately. The release in pressure causes the rock to expand, resulting in a series of cracks where the surface layers spall off. Production of these layers is referred to as sheeting. Especially in homogeneous rocks, sheeting results in a mechanical weathering process known as exfoliation. A further extension of exfoliation is spheroidal weathering, where these homogeneous rocks weather chemically more quickly along the joints and produce rounded erosional features. Water can work its way into various cracks, voids, and crevices in rocks. At night, the water can freeze. As the water freezes, it expands with great force, enough that it may widen any weakness that existed before. The next morning, the water may melt, and the liquid water can now move even further into the space that was widened. This can happen over and over, night after night, eventually prying rocks apart. Root Wedging The roots of this tree are demonstrating the destructive power of root wedging. Though this picture is a man-made rock asphalt , it works on typical rock as well. Similar to frost wedging, root wedging is the process in which plants work themselves into cracks, prying the bedrock apart as the roots grow. Rhizolith is the term for these roots preserved in the rock record. Other biological agents that do similar weathering include tunneling organisms such as earthworms, termites, and ants. Also similar to frost wedging, areas with high evaporation or near-marine environments can produce various salts that grow and expand, similar to ice, and produce and extend cracking in bedrock. They are also one of the causes of tafoni, which are a series of holes in a rock. Once a tafoni is started, it becomes a location of increased mechanical and chemical weathering. However, their surface areas are vastly different. The surface area to volume ratio SA: V , which is related to the amount of material available for reactions, changes for each as well. On the right, the SA: Chemical weathering dominates in warm, humid environments and is the process by which water, oxygen, and other reactants chemically break down components of bedrock into ions that dissolve into the water. This process goes hand-in-hand with mechanical weathering because of a fundamental concept called surface-area-to-volume ratio. Chemical weathering can only occur on the surface of the rock in question, not in the interior. As mechanical weathering breaks bedrock into smaller pieces each of which have surfaces, it creates more area for chemical weathering to occur, thus increasing the rate of chemical weathering overall. So, with more surface area, caused by mechanical weathering, chemical weathering is enhanced. In other words, a higher surface-area-to-volume ratio means a higher rate of overall weathering. Temperature also increases chemical weathering rates. Carbonic Acid and Hydrolysis Generic hydrolysis diagram, where the bonds in mineral in question would represent the left side of the diagram. This happens naturally in clouds; precipitation is thus weakly acid. Carbonic acid is important in the reactions called hydrolysis and dissolution. An example of the hydrolysis reaction affecting silicates in chemical weathering can be expressed approximately in words: This is the main process that breaks down silicate minerals and creates clay minerals. Clay minerals are a large family of platy silicates similar to micas and are the main components of very fine grained sediment. Some sedimentary minerals, such as evaporites like salt and carbonates like calcite in limestone , are much more prone to this reaction, but all minerals are subject to dissolution. Natural rainwater can be highly acidic, containing pH levels as low as 2. Places that contain higher levels of acid, either naturally or man-made, can dissolve at a higher rate. Humid regions and places with more precipitation also have more dissolution. This mantle xenolith containing olivine green is chemically weathering by hydrolysis and oxidation into the pseudo-mineral iddingsite, which is a complex of water, clay, and iron oxides. The more altered side of the rock has been exposed to the environment longer. Even without acid present, water will naturally dissolve all minerals, though some at very slow rates. Therefore quartz, crystallizing at around oC is very resistant to chemical weathering and high-temperature olivine and pyroxene, crystallizing at around oC weather much more rapidly and are rarely found in products of chemical weathering. Eroded karst topography in Minevre, France. Dissolution is also noteworthy for the special features that form because of it. In places with an abundance of carbonate bedrock which is susceptible to dissolution, a landscape is formed called karst topography, and is characterized by geographic features like sinkholes and caves see Chapter The figure shows a formation in Timpanogos Cave precipitated from calcite dissolved in groundwater that now seeps into the cavern. Dissolution can also have a biologic component, where organisms like lichen and bacteria aid in mineral dissolution with the release of organic acids, or even mineral components being used in metabolism by the organisms. Oxidation Pyrite cubes are oxidized, becoming a new mineral goethite. In this case, goethite is a pseudomorph after pyrite, meaning it has taken the form of another mineral. Any minerals that contain iron can be involved in oxidation. Three new minerals are common results of this oxidation reaction: These minerals are common cements binding grains together in sedimentary rocks that formed on the surface, and often give a dominant color to the rocks. They are found coating sand grains in the red rock colors of the strata on the Colorado Plateau and famous protected lands within such as Zion, Arches, and Grand Canyon National Parks. These oxides can permeate a rock that is rich in iron-bearing minerals, or can be a coating that forms in cavities or fractures. When these minerals replace existing minerals in bedrock with strong minerals, iron concretions may occur in the rock. When bedrock is replaced by weaker oxides, this process commonly results in void spaces and weakness throughout the rock mass and often leaves hollows on exposed rock surfaces. The more resistant cap has protected the less resistant underlying layers. Erosion is the process that removes sediment from the place of weathering. Water is also important in erosion, as it is the main agent of erosion. Wind, ice, and even gravity are also important in the transportation of sediments. Grand Canyon from Mather Point. The primary adjective that is used in geologic studies of erosion is resistant. A rock that is more resistant to weathering and subsequent erosion will last longer than a less-resistant rock. This is perhaps best demonstrated in a place like the Grand Canyon. Any place in which a cliff forms indicates a resistant rock which is fighting erosion, and thus making the cliff. Places with slopes are less resistant, and those rocks are being eroded more quickly. Soil Sketch and picture of soil. Soil is formed at the transition between the biosphere and the geosphere and is a combination of minerals and organic matter. Soil is made as weathering breaks down bedrock and turns it into sediment but does not move the sediment significantly by erosion, allowing life to access the mineral components they need. Soil is a reservoir for important organic elements e. The organic material in soil called humus is a critical source for nitrogen. Nitrogen is the most common element in the atmosphere, and yet it is in a form that most life forms are unable to use. It is only special nitrogen-fixing bacteria only found in soil that can convert the nitrogen to forms usable by plants, and later, animals, and this is the source of the majority of nitrogen used by life. That nitrogen is an essential component of proteins and DNA. Soil, in addition to mineral and organic material, also contains air and water. Schematic of the nitrogen cycle. Soils range from poor to rich, that range being determined by the amount of organic matter humus contained within it. Soil productivity is determined by nutrients in the soil: Agricultural terracing, as made by the Inca culture from the Andes, helps reduce erosion and promote soil formation, leading to better farming practices. The nature of the soil depends primarily on four things: Lower angle topography in valleys promotes thicker soil development. Within the soil are fungi and bacteria and plant roots interact with them to exchange nitrogen and other nutrients. A simplified soil profile, showing labeled layers. Where soils are well formed, the processes of formation causes a noticeable sequence called a soil profile.

While the horizons of the profile in a given setting depend on climate, topography, and the other factors of soil development, these layers reflect the processes involved see figure. A series of letters are commonly assigned to the different layers. The following is a simplified lettering, though many differences occur in these naming schemes depending on the area, soil type or topic of research. The following is a common designation. The top layer, O, is a thin layer of organic material composed of leaves, twigs, and other plant matter in the process of decaying into humus. The next layer, A, also known as the topsoil, is organic material humus mixed with some mineral material. As precipitation soaks down through this material, it leaches out soluble chemicals. In wetter climates, this zone is recognizable and is referred to as the zone of leaching or eluviation.

Chapter 2 : 5 Weathering, Erosion, and Sedimentary Rocks â€“ An Introduction to Geology

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Middle Triassic marginal marine sequence of siltstones and sandstones, southwestern Utah. There are four primary types of sedimentary rocks: Clastic rocks are composed of particles derived from the weathering and erosion of precursor rocks and consist primarily of fragmental material. Clastic rocks are classified according to their predominant grain size and their composition. In the past, the term "Clastic Sedimentary Rocks" were used to describe silica-rich clastic sedimentary rocks, however there have been cases of clastic carbonate rocks. The more appropriate term is siliciclastic sedimentary rocks. Organic sedimentary rocks are important deposits formed from the accumulation of biological detritus, and form coal and oil shale deposits, and are typically found within basins of clastic sedimentary rocks Carbonates are composed of various carbonate minerals most often calcium carbonate $CaCO_3$ precipitated by a variety of organic and inorganic processes. Typically, the majority of carbonate rocks are composed of reef material[citation needed]. These include jaspilite and chert. Importance of sedimentary rocks[edit] Mi Vida uranium mine in redox mudstones near Moab, Utah Sedimentary rocks provide a multitude of products which modern and ancient society has come to utilise. Coal and oil shale are found in sedimentary rocks. Our understanding of the extent of these aquifers and how much water can be withdrawn from them depends critically on our knowledge of the rocks that hold them the reservoir. Basic principles[edit] Heavy minerals dark deposited in a quartz beach sand Chennai , India. Sedimentological conditions are recorded within the sediments as they are laid down; the form of the sediments at present reflects the events of the past and all events which affect the sediments, from the source of the sedimentary material to the stresses enacted upon them after diagenesis are available for study. The principle of superposition is critical to the interpretation of sedimentary sequences, and in older metamorphic terrains or fold and thrust belts where sediments are often intensely folded or deformed, recognising younging indicators or graded bedding is critical to interpretation of the sedimentary section and often the deformation and metamorphic structure of the region. Folding in sediments is analysed with the principle of original horizontality , which states that sediments are deposited at their angle of repose which, for most types of sediment, is essentially horizontal. Thus, when the younging direction is known, the rocks can be "unfolded" and interpreted according to the contained sedimentary information. The principle of lateral continuity states that layers of sediment initially extend laterally in all directions unless obstructed by a physical object or topography. The principle of cross-cutting relationships states that whatever cuts across or intrudes into the layers of strata is younger than the layers of strata. Methodology[edit] Centripetal desiccation cracks with a dinosaur footprint in the center in the Lower Jurassic Moenave Formation at the St. The methods employed by sedimentologists to gather data and evidence on the nature and depositional conditions of sedimentary rocks include; Measuring and describing the outcrop and distribution of the rock unit; Describing the rock formation , a formal process of documenting thickness, lithology, outcrop, distribution, contact relationships to other formations Mapping the distribution of the rock unit, or units Descriptions of rock core drilled and extracted from wells during hydrocarbon exploration Describes the progression of rock units within a basin Describing the lithology of the rock; Petrology and petrography ; particularly measurement of texture , grain size , grain shape sphericity, rounding, etc. The research, which appears in the December 14th, , edition of Science , counters the prevailing view of geologists that mud only settles when water is slow-moving or still, instead showing that "muds will accumulate even when currents move swiftly. Such rocks are widely used to infer past climates, ocean conditions, and orbital variations.

Chapter 3 : Sedimentary Geology - Donald R. Prothero, Fred Schwab - Google Books

Sedimentary Geology: An Introduction to Sedimentary Rocks and Stratigraphy / Edition 3 Focusing on basic principles of stratigraphy and sedimentary petrology, this textbook discusses sedimentary processes and their results, siliciclastic sediments and environments, biogenic and chemical processes and products, lithostratigraphy, biostratigraphy.

Common examples include limestone and dolostone. Evaporite sedimentary rocks are composed of minerals formed from the evaporation of water. Evaporite rocks commonly include abundant halite rock salt , gypsum , and anhydrite. Common examples include coal , oil shale as well as source rocks for oil and natural gas. Siliceous sedimentary rocks are almost entirely composed of silica SiO 2 , typically as chert , opal , chalcedony or other microcrystalline forms. This sediment is often formed when weathering and erosion break down a rock into loose material in a source area. The material is then transported from the source area to the deposition area. The type of sediment transported depends on the geology of the hinterland the source area of the sediment. However, some sedimentary rocks, such as evaporites , are composed of material that form at the place of deposition. The nature of a sedimentary rock, therefore, not only depends on the sediment supply, but also on the sedimentary depositional environment in which it formed. Transformation Diagenesis Pressure solution at work in a clastic rock. While material dissolves at places where grains are in contact, that material may recrystallize from the solution and act as cement in open pore spaces. As a result, there is a net flow of material from areas under high stress to those under low stress, producing a sedimentary rock that is more compact and harder. Loose sand can become sandstone in this way. Some of those processes cause the sediment to consolidate into a compact, solid substance from the originally loose material. Young sedimentary rocks, especially those of Quaternary age the most recent period of the geologic time scale are often still unconsolidated. As sediment deposition builds up, the overburden lithostatic pressure rises, and a process known as lithification takes place. Sedimentary rocks are often saturated with seawater or groundwater , in which minerals can dissolve, or from which minerals can precipitate. Precipitating minerals reduce the pore space in a rock, a process called cementation. Due to the decrease in pore space, the original connate fluids are expelled. The precipitated minerals form a cement and make the rock more compact and competent. In this way, loose clasts in a sedimentary rock can become "glued" together. When sedimentation continues, an older rock layer becomes buried deeper as a result. The lithostatic pressure in the rock increases due to the weight of the overlying sediment. This causes compaction, a process in which grains mechanically reorganize. During compaction, this interstitial water is pressed out of pore spaces. Compaction can also be the result of dissolution of grains by pressure solution. The dissolved material precipitates again in open pore spaces, which means there is a net flow of material into the pores. However, in some cases, a certain mineral dissolves and does not precipitate again. This process, called leaching , increases pore space in the rock. Some biochemical processes, like the activity of bacteria , can affect minerals in a rock and are therefore seen as part of diagenesis. Fungi and plants by their roots and various other organisms that live beneath the surface can also influence diagenesis. Burial of rocks due to ongoing sedimentation leads to increased pressure and temperature, which stimulates certain chemical reactions. An example is the reactions by which organic material becomes lignite or coal. When temperature and pressure increase still further, the realm of diagenesis makes way for metamorphism , the process that forms metamorphic rock. Properties A piece of a banded iron formation , a type of rock that consists of alternating layers with iron III oxide red and iron II oxide grey. BIFs were mostly formed during the Precambrian , when the atmosphere was not yet rich in oxygen. Moories Group , Barberton Greenstone Belt , South Africa Color The color of a sedimentary rock is often mostly determined by iron , an element with two major oxides: Iron II oxide FeO only forms under low oxygen anoxic circumstances and gives the rock a grey or greenish colour. Iron III oxide Fe2O3 in a richer oxygen environment is often found in the form of the mineral hematite and gives the rock a reddish to brownish colour. In arid continental climates rocks are in direct contact with the atmosphere, and oxidation is an important process, giving the rock a red or orange colour. Thick sequences of red sedimentary rocks formed in arid climates are called red beds. However, a red colour does not necessarily mean the rock formed in a continental environment or arid climate. Organic material is formed from dead organisms, mostly plants. Normally, such material eventually decays by oxidation or bacterial activity. Under anoxic circumstances, however, organic material cannot decay and leaves a dark sediment, rich in organic material. This can, for example, occur at the bottom of deep seas and lakes. There is little water mixing in such environments; as a result, oxygen from surface water is not brought down, and the deposited sediment is normally a fine dark clay. Dark rocks, rich in organic material, are therefore often shales. The texture is a small-scale property of a rock, but determines many of its large-scale properties, such as the density , porosity or permeability. Between the clasts, the rock can be composed of a matrix a cement that consists of crystals of one or more precipitated minerals. The size and form of clasts can be used to determine the velocity and direction of current in the sedimentary environment that moved the clasts from their origin; fine, calcareous mud only settles in quiet water while gravel and larger clasts are moved only by rapidly moving water. The statistical distribution of grain sizes is different for different rock types and is described in a property called the sorting of the rock. Coquina , a rock composed of clasts of broken shells, can only form in energetic water. The form of a clast can be described by using four parameters: Chemical sedimentary rocks have a non-clastic texture, consisting entirely of crystals. To describe such a texture, only the average size of the crystals and the fabric are necessary. Mineralogy Most sedimentary rocks contain either quartz especially siliciclastic rocks or calcite especially carbonate rocks. In contrast to igneous and metamorphic rocks, a sedimentary rock usually contains very few different major minerals. However, the origin of the minerals in a sedimentary rock is often more complex than in an igneous rock. Minerals in a sedimentary rock can have formed by precipitation during sedimentation or by diagenesis. In the second case, the mineral precipitate can have grown over an older generation of cement. Carbonate rocks dominantly consist of carbonate minerals such as calcite , aragonite or dolomite. Both the cement and the clasts including fossils and ooids of a carbonate sedimentary rock can consist of carbonate minerals. The mineralogy of a clastic rock is determined by the material supplied by the source area, the manner of its transport to the place of deposition and the stability of that particular mineral. In this series, quartz is the most stable, followed by feldspar , micas , and finally other less stable minerals that are only present when little weathering has occurred. In most sedimentary rocks, mica, feldspar and less stable minerals have been reduced to clay minerals like kaolinite , illite or smectite. Unlike most igneous and metamorphic rocks, sedimentary rocks form at temperatures and pressures that do not destroy fossil remnants. Often these fossils may only be visible under magnification. Dead organisms in nature are usually quickly removed by scavengers , bacteria , rotting and erosion, but sedimentation can contribute to exceptional circumstances where these natural processes are unable to work, causing fossilisation. The chance of fossilisation is higher when the sedimentation rate is high so that a carcass is quickly buried , in anoxic environments where little bacterial activity occurs or when the organism had a particularly hard skeleton. Larger, well-preserved fossils are relatively rare. Burrows in a turbidite , made by crustaceans , San Vincente Formation early Eocene of the Ainsa Basin , southern foreland of the Pyrenees Fossils can be both the direct remains or imprints of organisms and their skeletons. Most commonly preserved are the harder parts of organisms such as bones, shells, and the woody tissue of plants. Soft tissue has a much smaller chance of being fossilized, and the preservation of soft tissue of animals older than 40 million years is very rare. As a part of a sedimentary or metamorphic rock, fossils undergo the same diagenetic processes as does the containing rock. A shell consisting of calcite can, for example, dissolve while a cement of silica then fills the cavity. In the same way, precipitating minerals can fill cavities formerly occupied by blood vessels , vascular tissue or other soft tissues. This preserves the form of the organism but changes the chemical composition, a process called permineralization. In the case of silica cements, the process is called lithification. At high pressure and temperature, the organic material of a dead organism undergoes chemical reactions in which volatiles such as water and carbon dioxide are expulsed. The fossil, in the end, consists of a thin layer of pure carbon or its mineralized form, graphite. This form of fossilisation is called carbonisation. It is particularly important for plant fossils. Unlike textures, structures are always large-scale features that can easily be studied in the field. Sedimentary structures can indicate something about the sedimentary environment or can serve to tell which side originally faced up where tectonics have tilted or overturned sedimentary layers. Sedimentary rocks are laid down in layers called beds or strata. A bed is defined as a layer of rock that has a uniform lithology and texture. Beds form by the deposition of layers of sediment on top of each other. The sequence of beds that characterizes sedimentary rocks is called bedding. Finer, less pronounced layers are called laminae, and the structure a lamina forms in a rock is called lamination. Laminae are usually less than a few centimetres thick. In some environments, beds are deposited at a usually small angle. Sometimes multiple sets of layers with different orientations exist in the same rock, a structure called cross-bedding. Newer beds then form at an angle to older ones. The opposite of cross-bedding is parallel lamination, where all sedimentary layering is parallel. Laminae that represent seasonal changes similar to tree rings are called varves. Any sedimentary rock composed of millimeter or finer scale layers can be named with the general term laminite. When sedimentary rocks have no lamination at all, their structural character is called massive bedding.

Chapter 4 : Sedimentology - Wikipedia

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