ANALYSIS OF MATERIALS

4. THE STRUCTURE OF OTHER MATERIALS

4.1. Rock/Stone

Sedimentary rocks are types of rock that are formed by the deposition of material at the Earth's surface and within bodies of water. Sedimentation is the collective name for processes that cause mineral and/or organic particles (detritus) to settle and accumulate or minerals to precipitate from a solution. Particles that form a sedimentary rock by accumulating what are called sediment. Before being deposited, sediment was formed by weathering and erosion in a source area, and then transported to the place of deposition by water, wind, ice, mass movement or glaciers which are called agents of denudation.

The sedimentary rock cover of the continents of the Earth's crust is extensive, but the total contribution of sedimentary rocks is estimated to be only 8% of the total volume of the crust. Sedimentary rocks are only a thin veneer over a crust consisting mainly of igneous and metamorphic rocks. Sedimentary rocks are deposited in layers as strata, forming a structure called bedding. The study of sedimentary rocks and rock strata provides information about the subsurface that is useful for civil engineering, for example in the construction of roads, houses, tunnels, canals or other constructions. Sedimentary rocks are also important sources of natural resources like coal, fossil fuels, drinking water or ores. The study of the sequence of sedimentary rock strata is the main source for scientific knowledge about the Earth's history, including palaeogeography, paleoclimatology and the history of life. The scientific discipline that studies the properties and origin of sedimentary rocks is called sedimentology. Sedimentology is both part of geology and physical geography and overlaps partly with other disciplines in the Earth sciences, such as pedology, geomorphology, geochemistry or structural geology.

Properties

The color of a sedimentary rock is often mostly determined by iron, an element with two major oxides: iron(II) oxide and iron(III) oxide. Iron(II) oxide only forms under anoxic circumstances and gives the rock a grey or greenish color. Iron(III) oxide is often in the form of the mineral hematite and gives the rock a reddish to brownish color. 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 color. Thick sequences of red sedimentary rocks formed in arid climates are called red beds. However, a red color does not necessarily mean the rock formed in a continental environment or arid climate.

Clastic rocks have a 'clastic texture', which means they consist of clasts. The 3D orientation of these clasts is called the fabric of the rock. Between the clasts the rock can be composed of a matrix or a cement (the latter can consist 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 where the rock was formed; fine, calcareous mud only settles in quiet water, while gravel and larger clasts are only deposited by rapidly moving water. The grain size of a rock is usually expressed with the Wentworth scale, though alternative scales are used sometimes. The grain size can be expressed as a diameter or a volume, and is always an average value - a rock is composed of clasts with different sizes. The statistical distribution of grain sizes is different for different rock types and is described in a property called the sorting of the rock. When all clasts are more or less of the same size, the rock is called well-sorted, when there is a large spread in grain size, the rock is called poorly sorted.

4.2. Wood

The chemical composition of wood varies from species to species, but is approximately 50% carbon, 42% oxygen, 6% hydrogen, 1% nitrogen, and 1% other elements (mainly calcium, potassium, sodium, magnesium, iron, and manganese) by weight. Wood also contains sulfur, chlorine, silicon, phosphorus, and other elements in small quantity. Aside from water, wood has three main components. Cellulose, a crystalline polymer derived from glucose, constitutes about 41–43%. Next in abundance is hemicellulose, which is around 20% in deciduous trees but near 30% in conifers. It is mainly five-carbon sugars that are linked in an irregular manner, in contrast to the cellulose. Lignin is the third component at around 27% in coniferous wood vs 23% in deciduous trees. Lignin confers the hydrophobic properties reflecting the fact that it is based on aromatic rings. These three components are interwoven, and direct covalent linkages exist between the lignin and the hemicellulose. A major focus of the paper industry is the separation of the lignin from the cellulose, from which paper is made.

Sections of tree trunk

In coniferous or softwood species the wood cells are mostly of one kind, tracheids, and as a result the material is much more uniform in structure than that of most hardwoods. There are no vessels ("pores") in coniferous wood such as one sees so prominently in oak and ash, for example. The structure of hardwoods is more complex. The water conducting capability is mostly taken care of by vessels: in some cases (oak, chestnut, ash) these are quite large and distinct, in others (buckeye, poplar, willow) too small to be seen without a hand lens. In discussing such woods it is customary to divide them into two large classes, *ring-porous* and *diffuse-porous*. In ring-porous species, such as ash, black locust, catalpa, chestnut, elm, hickory, mulberry, and oak, the larger vessels or pores (as cross sections of vessels are called) are localized in the part of the growth ring formed in spring, thus forming a region of more or less open and porous tissue. The rest of the ring, produced in summer, is made up of smaller vessels and a much greater proportion of wood fibers. These fiber are the elements which give strength and toughness to wood, while the vessels are a source of weakness.

4.3. Textile Fibers

Traditional textile making tools from 14th century Persia

Textiles can be made from many materials. These materials come from four main sources: animal (wool, silk), plant (cotton, flax, jute), mineral (asbestos, glass fibre), and synthetic (nylon, polyester, acrylic). In the past, all textiles were made from natural fibres, including plant, animal, and mineral sources. In the 20th century, these were supplemented by artificial fibres made from petroleum. Textiles are made in various strengths and degrees of durability, from the finest gossamer to the sturdiest canvas. The relative thickness of fibres in cloth is measured in deniers. Microfibre refers to fibres made of strands thinner than one denier.

Animal Textiles

Animal textiles are commonly made from hair, fur, skin or silk (in the silkworms case). Wool refers to the hair of the domestic goat or sheep, which is distinguished from other types of animal hair in that the individual strands are coated with scales and tightly crimped, and the wool as a whole is coated with a wax mixture known as lanolin (sometimes called wool grease), which is waterproof and dirt proof. Woollen refers to a bulkier yarn produced from carded, non-parallel fibre, while worsted refers to a finer yarn spun from longer fibres which have been combed to be parallel. Wool is commonly used for warm clothing. Cashmere, the hair of the Indian cashmere goat, and mohair, the hair of the North African angora goat, are types of wool known for their softness.

Plant Textiles

In the case of plant textiles, Grass, rush, hemp, and sisal are all used in making rope. In the first two, the entire plant is used for this purpose, while in the last two, only fibres from the plant are utilized. Coir (coconut fibre) is used in making twine, and also in floor mats, doormats, brushes, mattresses, floor tiles, and sacking.

Straw and bamboo are both used to make hats. Straw, a dried form of grass, is also used for stuffing, as is kapok. Fibres from pulpwood trees, cotton, rice, hemp, and nettle are used in making paper. Cotton, flax, jute, hemp, modal and even bamboo fibre are all used in clothing. Piña (pineapple fibre) and ramie are also fibres used in clothing, generally with a blend of other fibres such as cotton. Nettles have also been used to make a fibre and fabric very similar to hemp or flax. The use of milkweed stalk fibre has also been reported, but it tends to be somewhat weaker than other fibres like hemp or flax. Acetate is used to increase the shininess of certain fabrics such as silks, velvets, and taffetas. Seaweed is used in the production of textiles: a water-soluble fibre known as alginate is produced and is used as a holding fibre; when the cloth is finished, the alginate is dissolved, leaving an open area. Lyocell is a man-made fabric derived from wood pulp. It is often described as a man-made silk equivalent; it is a tough fabric that is often blended with other fabrics – cotton, for example. Fibres from the stalks of plants, such as hemp, flax, and nettles, are also known as bast fibres.

Mineral textiles

Asbestos and basalt fibre are used for vinyl tiles, sheeting, and adhesives, transite panels and siding, acoustical ceilings, stage curtains, and fire blankets. Glass fibre is used in the production of spacesuits, ironing board and mattress covers, ropes and cables, reinforcement fibre for composite materials, insect netting, flame-retardant and protective fabric, soundproof, fireproof, and insulating fibres. Metal fibre, metal foil, and metal wire have a variety of uses, including the production of cloth-of-gold and jewelry. Hardware cloth (US term only) is a coarse woven mesh of steel wire, used in construction. It is much like standard window screening, but heavier and with a more open weave. It is sometimes used together with screening on the lower part of screen doors, to resist scratching by dogs. It serves similar purposes as chicken wire, such as fences for poultry and traps for animal control.

Synthetic Textiles

All synthetic textiles are used primarily in the production of clothing.

- **Polyester fibre** is used in all types of clothing, either alone or blended with fibres such as cotton.
- **Aramid fibre** is used for flame-retardant clothing, cut-protection, and armor.
- **Acrylic** is a fibre used to imitate wools, including cashmere, and is often used in replacement of them.
- **Nylon** is a fibre used to imitate silk; it is used in the production of pantyhose. Thicker nylon fibres are used in rope and outdoor clothing.
- **Spandex** (**trade name *Lycra***) is a polyurethane product that can be made tight-fitting without impeding movement. It is used to make activewear, bras, and swimsuits.
- **Olefin fibre** is a fibre used in activewear, linings, and warm clothing. Olefins are hydrophobic, allowing them to dry quickly. A sintered felt of olefin fibres is sold under the trade name Tyvek.

- **Ingeo** is a polylactide fibre blended with other fibres such as cotton and used in clothing. It is more hydrophilic than most other synthetics, allowing it to wick away perspiration.
- **Lurex** is a metallic fibre used in clothing embellishment.
- **Milk proteins** have also been used to create synthetic fabric. Milk or casein fibre cloth was developed during World War I in Germany, and further developed in Italy and America during the 1930s. Milk fibre fabric is not very durable and wrinkles easily, but has a pH similar to human skin and possesses anti-bacterial properties. It is marketed as a biodegradable, renewable synthetic fibre.
- **Carbon fibre** is mostly used in composite materials, together with resin, such as carbon fibre reinforced plastic. The fibres are made from polymer fibres through carbonization.

4.4. Plastics

Most plastics contain organic polymers. The vast majority of these polymers are based on chains of carbon atoms alone or with oxygen, sulfur, or nitrogen as well. The backbone is that part of the chain on the main path linking a large number of repeat units together. To customize the properties of a plastic, different molecular groups hang from the backbone (usually they are hung as part of the monomers before the monomers are linked together to form the polymer chain). The structure of these side chains influence the properties of the polymer. This fine tuning of the repeating unit's molecular structure influences the properties of the polymer. Most plastics contain other organic or inorganic compounds blended in. The amount of additives ranges from zero percentage (for example in polymers used to wrap foods) to more than 50% for certain electronic applications. The average content of additives is 20% by weight of the polymer. Many of the controversies associated with plastics are associated with the additives. Organotin compounds are particularly toxic. Fillers improve performance and/or reduce production costs. Stabilizing additives include fire retardants to lower the flammability of the material. Many plastics contain fillers, relatively inert and inexpensive materials that make the product cheaper by weight. Typically fillers are mineral in origin, e.g., chalk. Some fillers are more chemically active and are called reinforcing agents. Other fillers include zinc oxide, wood flour, ivory dust, cellulose and starch. Since many organic polymers are too rigid for particular applications, they are blended with plasticizers (the largest group of additives), oily compounds that confer improved rheology. Colorants are common additives, although their weight contribution is small.