Quadrant II – Transcript and Related Materials

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Notes

Siliceous sediment

Introduction

Chert is a general term for fine-grained siliceous sediment, of inorganic, biochemical, biogenic, volcanic or hydrothermal origin.

Chert is composed mainly of microcrystalline quartz, with minor chalcedony and opal.

Cherts are common rocks in geologic successions ranging in age from Precambrian to Tertiary; however, they make up only a minor fraction of all sedimentary rocks.

Geologists are particularly interested in cherts because of the information they provide about paleogeography, paleo-oceanographic circulation patterns, and plate tectonics.

Chert is composed dominantly of Si02 but may also include minor amounts of Al, Fe, Mn, Ca, Na, K, Mg, Ti, and a few other elements such as the rare earth elements cerium (Ce), europium (Eu), and lanthanum (La).

Varieties of Chert

Several informal names are applied to chert depending upon colour, inclusions, and texture.

Flint frequently is used as a synonym for chert and more specifically for chert nodules.

Jasper refers to a red variety of chert, its colour being due to finely disseminated hematite.

Porcelanite is a term used for fine-grained siliceous rocks with a texture and a fracture resembling those of unglazed porcelain.

Siliceous sinter is porous, low-density, light-colored siliceous rock deposited by waters of hot springs and geysers.

Cherts can be divided on the basis of gross morphology into two principal types: bedded cherts and nodular cherts.

Bedded cherts are further distinguished by their content of siliceous organisms of various kinds.

Bedded Chert

Bedded chert, also referred to as ribbon chert, consists of layers of nearly pure chert ranging to several centimetres thick that are commonly inter-bedded with millimetre thick partings or laminae of siliceous shale.

Bedding may be even and uniform or may show pinching and swelling.

Most chert beds lack internal sedimentary structures; however, graded bedding, cross-bedding, ripple marks, and sole markings have been reported in some cherts.

Bedded cherts are commonly associated with submarine volcanic rocks, pelagic limestones, and silici-clastic or carbonate turbidites.

Bedded cherts can be subdivided on the basis of type and abundance of siliceous organic constituents into four principal kinds:

diatomaceous deposits,

radiolarian deposits,

siliceous spicule deposits, and

bedded cherts containing few or no siliceous skeletal remains.

Diatomaceous deposits include both diatomites and diatomaceous cherts.

Diatomites are light-colored, soft, friable siliceous rocks composed chiefly of the opaline frustules of diatoms, a unicellular aquatic algae.Thus, they are fossil diatomaceous oozes.

Marine diatomites are commonly associated with sandstones, volcanic tuffs, mudstones or clay shales, clayey lime stones (marls), and, less commonly, gypsum.

Lacustrine diatomites are almost invariably associated with volcanic rocks.

When diatomaceous deposits are converted to quartz chert during diagenesis, the diatom tests are generally destroyed by dissolution and recrystallization.

2] Radiolarian Deposits consist predominantly of the remains of radiolarians, which are marine planktonic protozoans with a lattice like skeletal framework of opal.

Radiolarian deposits can be divided into radiolarite and radiolarian chert.

Radiolarite is the comparatively hard, fine-grained, chertlike equivalent of radiolarian ooze.

Radiolarian chert is well-bedded, microcrystalline radiolarite that has a well developed siliceous cement or ground mass.

3] Siliceous Spicule Deposits, Spicularite is a siliceous rock composed principally of the siliceous spicules of invertebrate organisms, particularly sponges.

Spicularite is loosely cemented in contrast to spicular chert, which is hard and dense.

Spicular cherts are mainly marine in origin and are associated with glauconitic sandstones, black shales, dolomite, argillaceous (clayey) limestones, and phosphorites.

Nonfossiliferous Cherts- Many bedded chert deposits have been described that contain few or no recognizable remains of siliceous organisms.

Nodular Chert

Nodular cherts are sub-spheroidal masses, lenses, or irregular layers or bodies that range in size from a few centimetres to several tens of centimetres.

They commonly lack internal structures, but some nodular cherts contain silicified fos-sils or relict structures such as bedding.

Nodular cherts typically occur in shelf-type carbonate rocks where they tend to be concentrated along certain horizons parallel to bedding.

Nodular cherts originate by diagenetic replacement. Diagenetic origin is clearly demonstrated in many nodules by the pres-ence of partly or wholly silicified remains of calcareous fossils or ooids.

Sedimentary phosphate deposits

Introduction

Sedimentary phosphate deposits or phosphorites are important natural resources.

Phosphates are one of the chief constituents of fertilizer and they are used widely in the chemical industry.

In addition, phosphorites commonly contain relatively high concentrations of useful elements such as uranium, fluorine and vanadium, and commonly are associated with organic rich mudstones, which are potential hydrocarbon source rocks.

Many sedimentary rocks contain a few per cent calcium phosphate in the form of grains of apatite, bone fragments or coprolites.

Sedimentary phosphate deposits are discussed here in three categories:

1] nodular and bedded phosphorites, where upwelling and organic productivity have played a major role in their formation.

2] bioclastic and pebble-bed phosphorites, where sediment reworking has been of paramount importance.

3] oceanic-island phosphorites, mostly related to guano.

Mineralogy

The most common sedimentary phosphate minerals are varieties of apatite.

The apatite of igneous rocks is chiefly fluorapatite, $Ca_5(PO_4)_3F$, but in sedimentary apatite replacement of the phosphate by carbonate may reach several per cent; sulphate may also replace the phosphate.

Fluorine may be replaced by hydroxyl or chlorine ions. In addition, the calcium ions may be replaced by sodium, magnesium, strontium, uranium and rare earths.

Most sedimentary phosphates are carbonate hydroxyl fluorapatites, which can be represented by the formula $Ca_{10}(PO_4,CO_3)_6F_{2-3}$.

The term collophane is often loosely applied to sedimentary apatite of cryptocrystalline form for which the precise composition is variable.

Principal Kinds of Phosphorite Deposits

Four kinds of phosphorite deposits are recognized : bedded, nodular, pebble bed, and guano.

The major phosphorite deposits are mainly bedded marine deposits.

Bedded phosphorites form distinct beds of variable thickness, commonly interbedded and interfingering with carbonaceous mudrocks, cherts, and carbonate rocks.

The phosphorite in bedded deposits occurs as peloids, ooids, pisoids, phosphatized brachiopods and other skeletal fragments, micrite-like apatite mud, and cements.

Bioclastic phosphorites are a special type of bedded phosphate deposit composed largely of vertebrate skeletal fragments such as fish bones, shark teeth, fish scales, and coprolites.

Deposits composed mainly of invertebrate fossil remains such as phosphatized brachiopod shells are also known.

These phosphate-bearing organic materials commonly become further enriched in P205 during diagenesis and may be cemented by phosphate minerals.

Nodular phosphorites are brownish to black, spherical to irregularly shaped nodules ranging in size from a few centimetres to a meter or more.

Internal structure of phosphate nodules ranges from homogeneous (structureless) to layered or concentrically banded. Phosphatic grains, pellets, shark teeth, and other fossils may occur within the nodules.

Pebble-bed phosphorites are composed of phosphatic nodules, phosphatized limestone fragments, or phosphatic fossils that have been mechanically concentrated by reworking of earlier formed phosphate deposits.

Guano deposits are composed of bird and bat excrement that has been leached to form an insoluble residue of calcium phosphate. Guano deposits are not important in the geologic record.

<u>**Origin of Phosphorites**</u>

Chemical/Biochemical Processes

The principal phosphate minerals in sedimentary rocks are various varieties of apatites, of which carbonate apatite [Ca10C03(P04)6] is particularly important.

Presumably, weathering of phosphorous-bearing rocks on land was the principal process that furnished phosphorus to the oceans, through river runoff, throughout geologic time.

Although a variety of inorganic mechanisms for extracting phosphorus from ocean water have been considered by geologists, biologic utilization of phosphate to build soft body tissue appears to provide the most feasible answer to the problem of phosphate concentration in sediments.

Modern phosphate nodules are forming in areas of oceanic upwelling where a steady supply of phosphate brought from the large, deep-ocean reservoir allows continuous growth of organisms in large numbers.

After death, organisms and organic debris not consumed by scavengers pile up on the ocean floor under reducing conditions where decay is inhibited.

These organic materials include the remains of phytoplankton and zooplankton, coprolites (feces), and the bones and scales of fish. All contain phosphorus; for example, phytoplankton contain about 0.4 percent phosphorus by dry weight.

Under the reducing conditions of the seafloor, some of the soft body tissue is thus preserved long enough to be buried and incorporated into accumulating sediment.

Slow decay of body tissue after burial releases phosphorus to the interstitial waters of the sediment.

Studies of the chemistry of interstitial waters in sediments where modern phosphate nodules are forming and in other areas of the seafloor where organic-rich sediments are accumulating under reducing conditions have reported phosphorus concentrations ranging from 1400 ppb to as much as 7500 ppb.

At such high phosphorus concentrations, the interstitial waters are supersaturated with respect to calcium phosphate.

The phosphate thus begins to precipitate on the surfaces of siliceous organisms, carbonate grains, particles of organic matter, fish scales, bones, siliciclastic mineral grains, or older phosphate particles.

Phosphate may also replace skeletal grains and carbonate grains, a process called phosphatization.

Phosphorite grains thus form within the sediments by diagenetic reactions between organic-rich sediments and their phosphate-enriched interstitial waters.

Physical Processes

The presence of clastic textures and primary depositional sedimentary structures in many ancient phosphorite deposits seems inconsistent with a diagenetic concentration mechanism.

Therefore, Kolodny (1980) suggested a two-stage process for the origin of ancient phosphorite deposits.

In the first stage, apatite forms diagenetically in reducing basins by mobilizing phosphorus in interstitial waters.

The final stage involves reworking and enrichment of these diagenetically formed phosphorite grains by mechanical concentration processes under oxidizing conditions.

Concentration presumably takes place in a high-energy environment, probably during lower stands of sea level.

During this stage, the phosphate grains may be transported into a different depositional setting than that in which they formed.

This final stage of phosphorite formation, during which the original diagenetically formed phosphorite sediments are mechanically reworked under shallow-water conditions, accounts for the clastic textures and primary sedimentary structures in many ancient phosphorites.