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Carbonates, Present and Future of Petroleum Production

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Introduction- Carbonates constitute the most abundant sediments and sedimentary rocks after terrigenous clastics. Carbonates are mainly formed by chemical, biochemical and biological processes, in contrast to sediments and rocks of terrigenous origin, which originate due to weathering and erosion of pre-existing material, arge percentage of carbonates are constituted in the marine environment, in coastal or tropical oceanic environments where clastic sedimentation is minimal or does not exist. These carbonates develop as reefs, platforms, atolls, banks, mounds, and ramps, as well as in the form of pelagic deposits in the oceans, for which a series of conditions is necessary, in the formation and accumulation of these sediments.

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Carbonates, Present and Future of Petroleum Production

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Introduction

Carbonates constitute the most abundant sediments and sedimentary rocks after terrigenous clastics. Carbonates are mainly formed by chemical, biochemical and biological processes, in contrast to sediments and rocks of terrigenous origin, which originate due to weathering and erosion of pre-existing material, arge percentage of carbonates are constituted in the marine environment, in coastal or tropical oceanic environments where clastic sedimentation is minimal or does not exist. These carbonates develop as reefs, platforms, atolls, banks, mounds, and ramps, as well as in the form of pelagic deposits in the oceans, for which a series of conditions is necessary, in the formation and accumulation of these sediments. In some lacustrine environments of tropical climate and lakes with high evaporation, carbonates will also form. Carbonates for their formation, either through direct precipitation or through organisms when building their shells and limestone skeletons, depend on the salinity and temperature of the water, the pH, the partial pressures of carbon dioxide, of dissolved oxygen, etc. The increase in salinity and temperature, the decrease in carbon dioxide, increase in oxygen and alkaline pH, favor the precipitation of calcium carbonate.

Image 1: Detritic Rocks: Conglomerates, sandstones, and kaolin shales (first). Utrillas Formation (Cretaceous), in Soria, Spain. Source: Geological and Mining Institute of Spain (IGME)

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Carbonate sediments and rocks contain more than 50% carbonate minerals, which are composed of CO3 2- and one or more cations. Calcite (CaCO3) is the most common mineral and the main component of limestone, followed by dolomite (CaMg (CO3) 2). Together these two minerals make up more than 90% of the rock-forming carbonate minerals during geological time. Limestones and dolomites can have varying amounts of quartz, feldspars, and clay minerals. In smaller quantities and locally, antigenic minerals such as chert, gypsum, anhydrite, and pyrite can be found. In recent carbonates, the common minerals are calcite and aragonite. Calcite is divided into calcite with high Mg (> 5% MgCO3) and calcite with low Mg (<5% MgCO3). Aragonite and calcite with high Mg are metastable and will invariably change to the stable form that is calcite with low Mg. These minerals are biochemically formed by some organisms, or by inorganic precipitation forming cement or constituents such as ooids and similarly occurred in the geological past. However, due to its condition of metastable minerals, Diagenetic changes will operate on aragonite and high calcium calcite, adapting a more stable form. Therefore all fossils with shells or skeletal parts, inorganic constituents and cements of these metastable minerals before the middle part of the Middle Pleistocene, will change to the stable form that is calcite with low Mg or simply calcite.

Image 2: Calcite is a form of calcium carbonate with the chemical formula, Source: British Geological Survey

In the sedimentary environments of modern carbonates, dolomite is not as usual as in the past since this mineral is constituted, by dolomitization processes from calcite, high magnesium calcite, and aragonite. However, the current models in which they are developing the dolomitization processes, such as areas of hypersaline lagoons, sabkhas areas of mixed meteoric and marine waters, among others, have allowed understanding, the processes and formation of the dolomites.

Diagenetic changes profoundly alter sediments and organisms formed by CaCO3. Most of these changes occur on the surface or by processes derived from it, during the early stages of burial. When the initial mineralogy is modified, the processes of lithification, formation of secondary cement, and transformation or creation of porosity manifest from the initial moment of deposition.

Carbonate minerals are found in numerous sedimentary environments, some terrestrial, but it is in tropical marine environments where they present a great abundance, both in the present and geological past, representing an excellent paleoclimatic indicator. Carbonate minerals are formed from carbonate saturated waters by biochemical processes developing the skeletal parts and shells of calcareous organisms, as well as by chemical precipitation of supersaturated waters forming concentric or radial laminations (ooids), and in environments with high evaporation or in the walls

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of caves and caverns by rapid decrease of CO2 (stalactites and stalagmites).

Image 3: Stalagmites in Carlsbad Caverns National Park, New Mexico. Source: Peter Jones. https://www.britannica.com/science/stalagmite

Limestones and dolomites represent between 1/5 to 1/6 of the global sediments and sedimentary rocks, and these can be known, more than any other group of sedimentary rocks, about the geological evolution of the Earth's surface. The sedimentary particles and the depositional texture of the limestones are indicative of environments, facies, current energy, erosion factors, etc. Limestone fossils represent the evolution of organisms, paleoenvironments, paleoclimates, and changes in sea level, from the Precambrian to the present day. The chemical composition of limestone and dolomites and the content of fossils, indicate the physicochemical characteristics of fluids and the environment and the conditions of temperature, salinity, water depth, oxygenation, etc.

Carbonate classifications have more complexity than those used for clastic sediments such as sandstones. Textural characteristics or chemical composition, depositional texture, génesis, and recognition of the components are necessary for a good classification. The wide variety of porosities, origin, and modification of these, as well as their relationship with the initial depositional environments, and underground stages, create an inexhaustible topic of discussion in carbonates.

Using, isotopic measurements with oxygen used by calcareous organisms, mainly some species of planktonic foraminifera, paleotemperature values, and glaciation, and interglaciation states are obtained. In this way, sea level change curves have been developed, during the Tertiary and Quaternary.

Limestones and dolomites generally constitute aquifers, and hydrocarbon deposits, as well as deposits of zinc, lead, silver and mercury. As important hydrocarbon reservoirs, they represent approximately 50% of the world's basins. In the deposits of the Persian Gulf and in Mexico, most of the hydrocarbon deposits are stored in limestones and dolomites. There are also important reservoirs in the Lower Cretaceous in some regions of the United States (mainly in Texas), as well as in various Paleozoic calcareous facies in Canada and the United States. In North Africa, mainly Libya and Algeria, hydrocarbon deposits are found in carbonates, as well as in southern Russia. In Venezuela, most of the deposits correspond to sandstone facies, but important limestone and dolomite deposits are found in the Lower Cretaceous of the Maracaibo Lake basin, in front of Perijá and areas of tidal plains of the Barinas region (Cenomaniense). Some limestones can be used in the chemical industry as a source of CaO, as well as for cement production and use in the construction industry.

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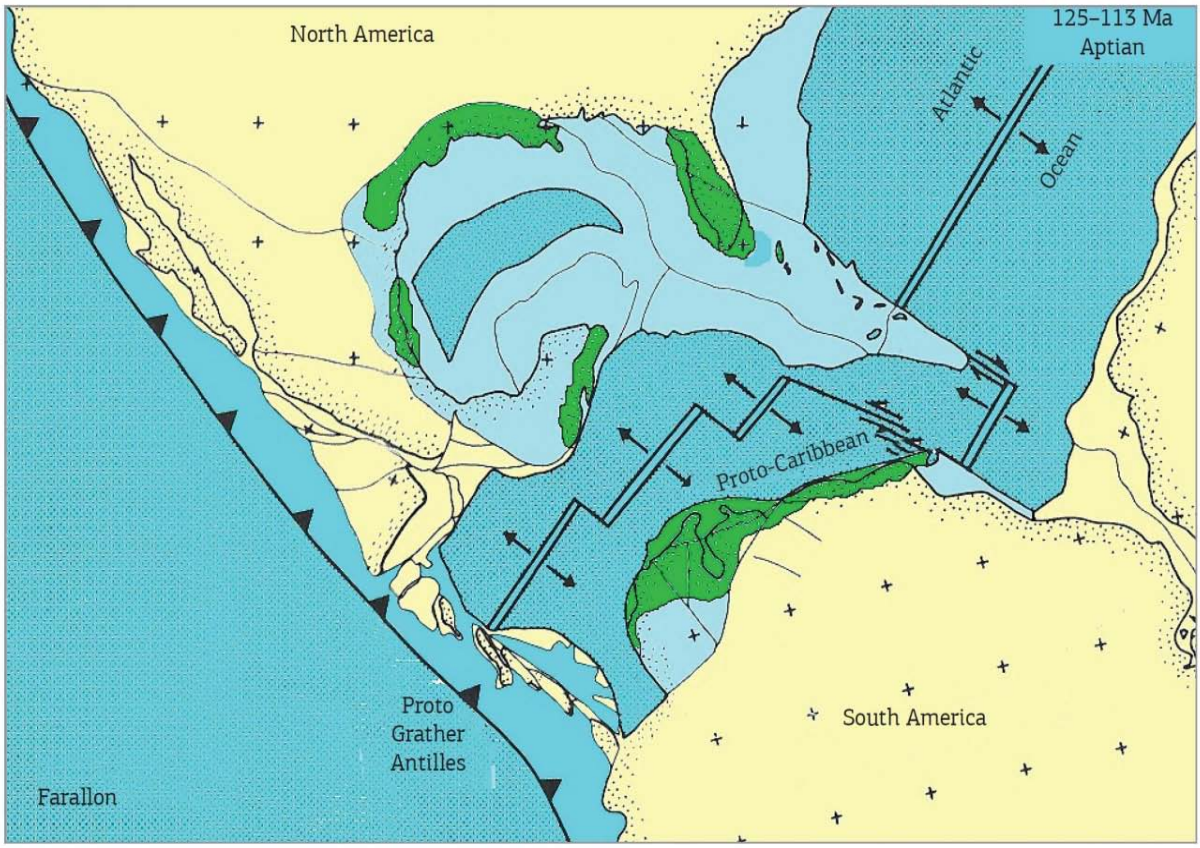

Image 4: Areas of carbonate platforms during the early Aptian (in green). In Venezuela, these carbonate systems were developed in the Maracaibo and Oriente basins. Part of these systems is also found in the East of Colombia, in outcrops and subsoil. Source: Brazilian Magazine of geology.

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