actualistic method for the study of fossils and sedimentary rocks and his founding of the science of comparative lithology. Comparative lithology was seen by Walther as the analogue for sedimentary rocks of comparative anatomy for fossils. It has been neglected in the western world until the recent revival of the concept of facies models.

Walther's law was the key concept within comparative lithology, and was originally stated as follows: "The various deposits of the same facies areas and similarly the sum of the rocks of different facies areas are formed beside each other in space, though in cross-section we see them lying on top of each other. As with biotopes, it is a basic statement of far-reaching significance that only those facies and facies areas can be superimposed primarily which can be observed beside each other at the present time."

In Russia, Walther's writings appear to have had a far greater influence than they have in Europe and America. They have been partly responsible for the development there of "lithology" as a branch of the geological sciences separate from stratigraphy or petrology.

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Pleistocene Ice-Rafted Pebble Abundance, Eastern North Atlantic Ocean

Detailed examination of a suite of 8 deep-sea cores collected by USNS *Kane*, north of 48°N lat., in the eastern North Atlantic Ocean indicates an unusually high abundance of coarser than sand-size-rafted debris. An average of 3 pebbles per core, each weighing greater than 8 g, characterizes the suite. In fact, the average weight for all pebbles found was 30 g. Assuming that these averages are compatible for the rest of the eastern North Atlantic, and assuming an average age of 300,000 years for the 8 cores, it has been calculated that over 2.6×10^{13} metric tons of coarse debris has been transported from Europe, Iceland, and the Faeroe Islands by ice-rafting since late middle Pleistocene time. If coarse debris represents a total of only 20% of all ice-rafted sediment, then in the eastern North Atlantic, over 1.3×10^{14} metric tons of sediment has been ice-rafted in the last 300,000 years.

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Evaluating Source Beds for Petroleum

Geochemists have made considerable progress in recent years in evaluating source beds for crude oil and natural gas. Petroleum is generated from disseminated sedimentary organic matter by thermochemical processes. A certain amount of time and temperature (thermal energy) is essential to produce the thermal cracking reactions causing the generation of petroleum. As the temperature is raised, the time for the reactions to occur is decreased. The same thermochemical processes that result in the generation of oil and hydrocarbon gases also contribute to the maturation and the ultimate destruction of oil and natural gas. Methane and graphite are the stable end products of these reactions. The exposure time-temperature relations necessary for the generation of petroleum and its expulsion from the source bed have been determined with sufficient accuracy from geochemical data to permit predictions of the approximate stage of generation or diagenesis in advance of sample analysis. Also, the conditions under which oil and condensate are thermally destroyed have been reasonably well established from empirical data. Geochemists are gradually improving their understanding of the factors that control source-bed performance. Factors such as the minimum amount and quality of organic matter necessary for effective oil source beds have been quantified rather accurately.

A balanced program includes evaluation of both the extractable organic matter and the residual organic matter in a source bed. The evaluation of extractable organic matter includes conventional analyses of organic carbon, total extractable organic matter, and extractable hydrocarbons. Evaluation of the extractable organic matter and extractable hydrocarbons include the study of heavy (C_{15}-C_{30}) hydrocarbon distributions and infrared spectra. Elemental analysis of carbon, hydrogen, nitrogen, and oxygen is a method used to investigate the diagenetic (carbonization) stage of residual organic matter. Pyrolysis techniques have been developed to investigate organic matter from the standpoint of its remaining generating capability.

Examples from the literature confirm that, in general, young source beds must be exposed to sustained higher temperatures than old source beds to attain peak generation. If 2 source beds of the same age and with identical burial histories were subjected to significantly and uniformly different temperatures, the hotter would be in a more advanced stage of organic matter diagenesis.

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Factors Which May Affect Occurrence of Gas in San Juan and Uinta Basins, Rocky Mountains

The San Juan basin, northwestern New Mexico, has long produced methane gas which commonly carries sufficient liquids to yield high BTU values. With this production, however, there have been wells which produced only carbon dioxide, or such large quantities of nitrogen as to be of very little economic value.

Early production came largely from the Dakota sandstones (Cretaceous) the gases of which contain an average of 80% methane and 15% higher hydrocarbons. Nitrogen and carbon dioxide average less than 3% and 1% respectively, yielding an average BTU of 1,194.

Later exploration has proved extensive gas reserves in the uppermost sequence of Upper Cretaceous sandstones, where the gases average 85% methane and 12% higher hydrocarbons. Nitrogen and carbon dioxide values are 1% or less and BTU values average 1,133.

Deeper exploration has shown a plethora of problems in the occurrence of gas in this basin. Gas from Permian, Pennsylvanian, and Mississippian reservoirs shows quantities of hydrocarbons much lower than in shallower formations, and nitrogen content as high as 81%. These nitrogen-rich gases carry some of the highest percentages of helium in the entire basin, from 3% to as high as 7.5%, although the production and reserves of Paleozoic rocks are several orders of magnitude smaller than those of the Cretaceous.

Characteristics of the gases in each group or sequence of formations are presented as related to depth of production. Economic factors may be evaluated on the basis of production from different zones at deeper levels. Wide variations in analyses appear to be related to the genesis of the reservoir rocks and to the geologic history of these deeper zones. Analyses of gas from individual sequences indicate isolated production from lenses in which gas has had very little opportunity to mingle with other, more widespread, gases from blanket-type sandstones.

Analyses of gases from the Uinta basin, eastern Utah, may be separated into those from Tertiary, Paleocene-Upper Cretaceous, lower Upper Cretaceous; Jurassic; and Pennsylvanian production. Pressures are related approximately to depths of production. The percentages of methane and total hydrocarbons are highest in the Eocene Wasatch gases, although the deeper gases exhibit a much higher content of the higher hydrocarbons, and these yield a high BTU value.

Percentages of nitrogen are low in the Tertiary reservoirs and increase to as much as 19% in the Pennsylvanian. Carbon dioxide values are variable, and helium values increase as the nitrogen values increase. Variations appear to be dependent on geologic environments rather than on depth only.

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LOWER CRETACEOUS CARBONATE BEACHES

Several carbonate beach sequences have been recognized and studied in Lower Cretaceous shallow-marine shelf limestones of the Edwards Formation, Central and West Texas. These sandstone bodies are local features associated with exposed insular areas developed in response to remnant structural features combined with biologic and normal sedimentologic processes (sand banks and rudist reefs).

From top to bottom, 4 zones are recognized: backshore, beach foreshore, upper offshore, and lower offshore. The backshore consists of laminated, mudcracked, fine-grained supratidal dolomite with gypsum molds and associated paleosoils. Thin washover deposits of coarse calcareous sands are common. The beach foreshore consists of a coarse rudist carbonate grainstone with a subaerial crust developed at the top. The dominant sedimentary structures are inclined laminations, accretion bedding, and "keystone vugs." Collapsed beachrock slabs are common. The upper offshore consists of poorly sorted rudist carbonate packstone with some finely interbedded coarse rudist carbonate grainstone and pellet carbonate packstone. This zone may contain festoon crossbedding trending normal to the direction of beach accretion. Beach rock cobbles derived from the beach foreshore zone above are common. The lower offshore zone consists of an echinoid-pellet carbonate packstone with common burrows and some festoon crossbedding.

Useful criteria for the recognition of ancient carbonate beaches are: vertical sequence of sedimentary structures, from accretion beds at top to burrows at base; vertical sequence of texture and fabric from coarse, well-sorted grainstones at top to poorly sorted fine-grained packstones at base; presence of evaporative supratidal facies at the top of the sequence; and association of keystone vugs and beachrock slabs with the accretion-bedded part of the sequence.

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SUBMARINE MEGABRECCIA DEBRIS FLOWS AND SLUMPED BLOCKS OF DEVONIAN OF AUSTRALIA AND ALBERTA—A COMPARISON

Large allochthonous blocks up to several tens of meters across are adjacent to reef-fringed isolated carbonate buildups and platforms in the Canning basin of Western Australia and in western Canada. Distinctive criteria such as geopetal fabrics, stratification, lack of facies changes within the blocks, enclosure within basin sediments, and occurrence several kilometers from the nearest buildups indicate the blocks and breccias are allochthonous, although often misinterpreted as in-place bioherms. Framebuilding reef-core facies is the predominant block type, hence most were derived from the margins of carbonate buildups.

In Australia they occur as isolated blocks and contain abundant stromatoporoids and *Renalcis*, interpreted as reef-core facies, increasing in number toward the carbonate platforms. Some of the blocks have disrupted the underlying basin sediments. A few debris beds of finer breccia beds (fragments floating in carbonate mud matrix) wedge out laterally and presumably formed shallow "channels" perpendicular to the carbonate platforms.

In Canada isolated blocks are unknown. Locally megabreccia beds flank some of the buildups and extend several kilometers into the basin. More common are finer breccias in beds and channels. Both types consist of disoriented, angular fragments of reef-margin stromatoporoid and coral facies, external lagoon facies, and basin mud in a pervasive dark, interstitial dolomitized micrite of basin origin.

The isolated blocks represent material tumbled into the adjacent basin, apparently during times of active slumping of the platform margins. The Canadian deposits apparently were transported by submarine debris flows analogous to subaerial mudflows from buildup margin environments when relief and slope at the margins were greatest.

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SIZE TRENDS OF SOME LIVING INVERTEBRATE GROUPS WITH CALCAREOUS SHELLS

The size of each species having a calcareous shell was recorded in at least 10 Holocene faunas of the following groups: marine, freshwater, and land gastropods; marine and freshwater pelecypods; and benthonic Foraminiferida. No pelecypod species living in the Arctic, the Antarctic, or the deep sea (2,000 m or deeper) attains a size of 100 mm. No marine gastropod species living in the Arctic or Antarctic attains a size of 150 mm. The largest living species of marine gastropods and pelecypods live in the western part of the Pacific and eastern part of the Indian Ocean. The largest living calcareous Foraminiferida also lives in the same general region. More large-size freshwater pelecypods live in warm water, and this trend applies to a lesser extent to freshwater gastropods. The largest freshwater gastropods and pelecypods, as well as the largest land gastropods, all live in the lower latitudes. Large calcareous Foraminiferida live in warm water, but large agglutinated Foraminiferida live in cold water.

Some geographic anomalies occur, and one of these is the uncommonly high percentage of small-size (10 mm or less) species of marine gastropods and pelecypods in the Antarctic.