Table 1. Hopcalite catalyzed oxidation of nitrogen compounds. The space velocity was 21,000 hr^{-1} and the temperature was 315°C.

Compound	Introduced concen. (ppm)	N_2O formed (% theoretical)
Ammonia*	140	70
Monoethanolamine*	19	20
Morpholine	35	16
Pyridine	40	17

* Raising the furnace temperature diminished the yield of N_2O from monoethanolamine and ammonia.

also report the production of nitrous oxide from ammonia with similar catalysts. With Hopcalite catalyst, an unsupported mixture of copper and manganese oxides, in an apparatus previously described (*4*), the same yield of nitrous oxide from ammonia was obtained. In addition, I obtained yields of nitrous oxide from organic progenitors in the range 16 to 20 percent (see Table 1).

Since there was no attempt to obtain maximum production of nitrous oxide, it may well be that there are conditions of temperature and space velocity (volumes of air stream per volume of catalyst per hour) which would result in greater yields of this substance with the same catalyst. Nitrous oxide concentrations in the catalytic reactor effluent were obtained by gas chromatographic comparisons with known gas mixtures prepared in stainless-steel pressure bottles. All three of the organic compounds studied, representing distinct structural types, produced the theoretical amount of carbon dioxide equivalent to complete combustion. In a separate experiment in which the concentration of ammonia introduced was 352 parts per million (ppm), less than 5 parts per million of nitrogen dioxide were detected in the reactor effluent. This indicates that the major product of the Hopcalite-catalyzed oxidation of ammonia is nitrous oxide, the remainder of the ammonia probably being converted to nitrogen and water.

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8 November 1963

Sea Level Changes in the Past 6000 Years: Possible Archeological Significance

Abstract. *Evidence from many stable areas indicates that sea level has risen slowly during the past 6000 years, with a total change of about 6 meters. Since the same period is also important in the history of man, the rise in sea level explains the widespread submergence of building sites and other human relics along coasts where ancient man lived.*

The changes in sea level which accompanied the melting of the great ice sheets of the last glacial episode are important because knowledge of such changes can guide archeologists in their search for the habitation of ancient man in coastal areas. Such information can also be used for establishing the relative stability of many coastal areas during recent millennia; and it is important for coastal geomorphologists to know how long, if at all, the sea level has been at its present position.

Currently, there are three schools of thought relative to the changes in sea level which have taken place during the past 6000 years. (i) The sea has fluctuated repeatedly from about 1.5 m below to 3 m above the present level. This has been maintained in many articles by Fairbridge (*1*). (ii) Sea level has been constant during most or all of this period. This has been defended by Fisk (*2*) and by McFarlan (*3*), and has been a common opinion among Gulf Coast geologists. (iii) The rate at which sea level was rising decreased about 5000 to 6000 years ago, but the level has continued to rise slowly up to the present. This opinion has come from the dating of samples in various stable coastal areas, and was first expressed in 1956 by Shepard and Suess (*4*) and further documented in 1963 (*5*).

It should now be possible to settle this controversial history by utilizing the large number of new carbon-14 dates established for costal areas. In establishing the history of sea level it is necessary to obtain elevations and dates either of organisms that lived at or near sea level, or of salt marsh peat. These samples should come from areas that appear to have been as free from warping movements as possible.

Actually, no area has been entirely stable in the past, so all one can do is to avoid areas such as those where there has been upwarping due to isostatic recovery from ice loads; where deltas like the Mississippi are known to be sinking at a very appreciable rate; where there has been recent mountain-building; or where earthquakes indicate instability. The following have been considered as satisfactory areas, partly because many samples from them have been dated: the shelf and coastal area of Texas, the coastal waters around Florida, and the lowlands of the Netherlands. Samples from a number of other areas that are probably equally stable have been compared with the dates from these three, and all of the information is plotted in Fig. 1. It will be seen that the result is highly favorable to the third hypothesis of a slow rise during the past 6000 years. The chief exceptions are from Australia, but recent work along that coast indicates that the dates from these samples are unreliable indices of rises in sea level (*6*).

If the sea had fluctuated in the manner suggested by Fairbridge, lowland areas that have been examined in great detail like the coasts of Texas and Louisiana, South Florida, and the Netherlands, would have yielded clear indications of high sea level during the postglacial period. No such evidence exists, as is clearly shown by Gould and McFarlan (*7*), Scholl (*8*), and Jelgersma (*9*) for the three areas.

Further substantiation of the general curve comes from a large number of dates from the East Coast published by Redfield and Rubin (*10*), Stuiver and Daddario (*11*), Bloom and Stuiver (*12*), and McIntire and Morgan (*13*). Previously, it had been supposed that the East Coast, particularly in marginal glaciated areas, could not be used for this purpose, but plotting of the dates against depth (Fig. 2) shows almost the same history of rise that was established from the localities used in Fig. 1. The only difference is that for the past 7000 years, dates from the

East Coast occur on the plot slightly below the line for the average of the other areas, suggesting either that very slow sinking has occurred, or that there might have been a difference in methods of analysis; alternatively, recycled material might be included in many of the dates shown in Fig. 1. It seems evident that the East Coast has not undergone the gyrations claimed by Fairbridge, nor is there any indication that sea level has been constant during the past 5000 or 6000 years.

The earlier suggestion of high sea level during the postglacial period was based largely on the fresh appearance of terraces on Pacific islands. These still remain somewhat of an enigma, although the terraces of Oahu, which are supposed to be 1.5 m and 3 m in elevation, have been dated by the carbon-14 method as 24,000 to 32,000 years old (*5*), and hence prior to the last maximum glaciation. A 3.3-m terrace in New Caledonia proved too old to date. However, many other slightly elevated reefs and terraces are found throughout the Pacific islands, and it will be significant if these give any evidence of uniformity that might bear on the history of sea level. Meantime, the data now available indicate that in postglacial times the sea has not risen appreciably above its present level, and that it has continued to rise slightly, perhaps intermittently, up to modern times.

The evidence that the sea has risen even during the past 2 millennia is particularly important to history since we have such excellent records of civilization during that period. The Mediterranean has not been entirely a stable area, so that drowning of old coastal habitations bordering this sea is not by itself substantial evidence of changes in sea level. However, the indicated rise in sea level of 1.5 m during the past 2 millennia would have caused many of the houses built along the shore to become submerged during the classical periods. It is interesting to find that Hafemann, (*14*) reported that a submergence of 2.5 m was the average for this period along the coasts of the Mediterranean, slightly greater than the rise in sea level but again within experimental error.

The rise in sea level during the past 5000 years has been important to archeology along another coast where instability might have been expected. The extensive Scuba diving along

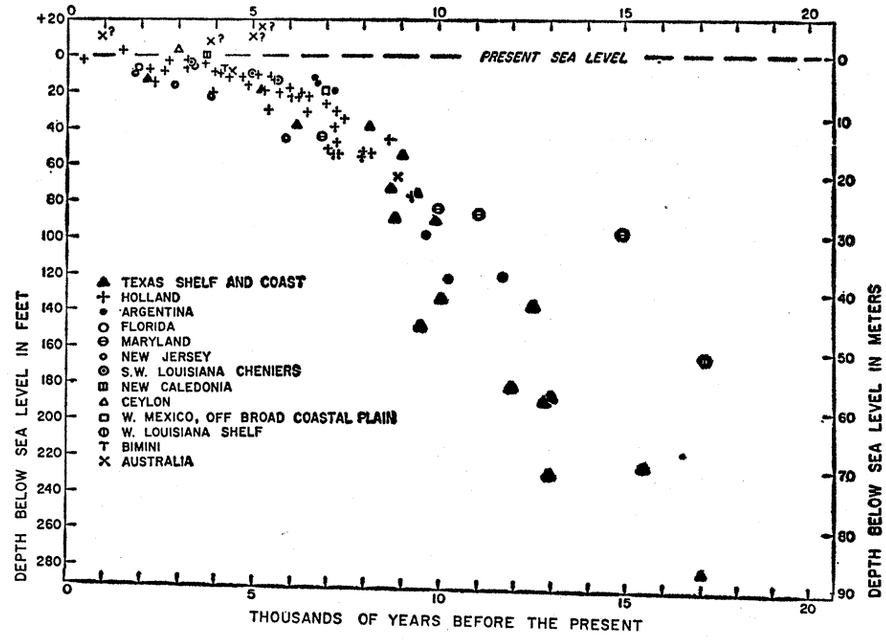

Fig. 1. Elevation and age of carbon-14–dated samples of organisms or plants that lived near sea level in relatively stable areas. The samples from Australian terraces are questioned because of the new evidence that they may represent kitchen middens.

southern California coastal areas has yielded thousands of small mortars left by the Indians who lived along the shore from a period dating back to at least 5000 years ago. Moriarty, Shumway, and Warren (*15*) report that shells found buried within the ancient Indian middens in the La Jolla area come from embayments such as would have existed in the heads of the local submarine canyons during a period of lower sea level. Finally, the report by

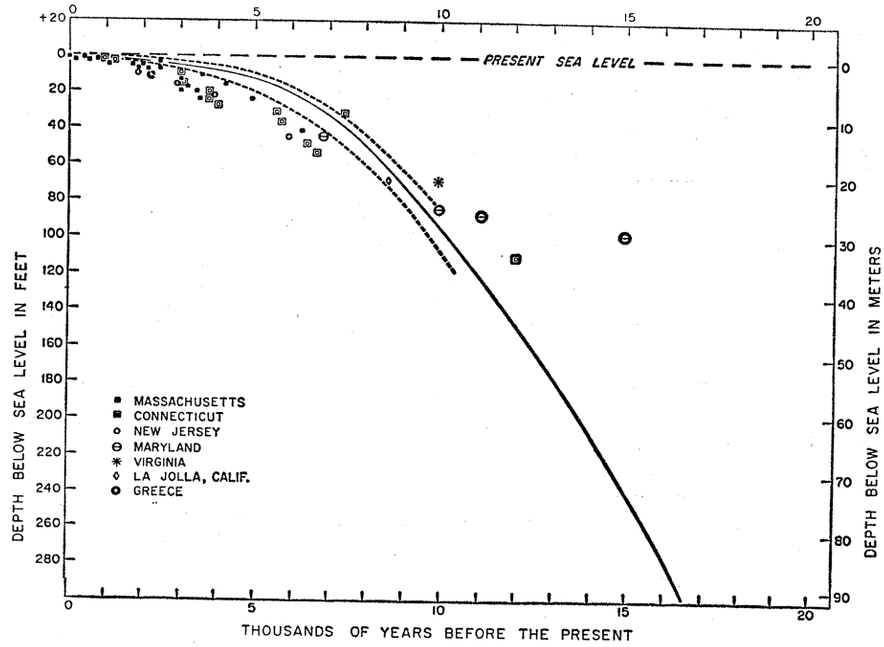

Fig. 2. Elevation and age of carbon-14–dated samples from the East Coast of the United States. Included also are samples from a canyon off La Jolla, California, and from an average submergence 2200 years ago of ancient coastal towns in Greece and other parts of the Mediterranean. The solid line represents a somewhat simplified average curve from Fig. 1, and the dashed curves represent quartiles from the same data.

Dill (*16*) of the finding of salt marsh peat in La Jolla Submarine Canyon with a carbon-14 age of 8800 years at a depth of 21 m below sea level provides further confirmation that at least this portion of southern California has been stable in recent times.

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Fossilized Stomach Contents of a Sauropod Dinosaur

Abstract. *A mass of petrified plant and bone fragments found in the late Jurassic Morrison formation of southwestern Emery County, Utah, appears to be the stomach contents of a sauropod dinosaur, skeletal remains of which were associated with it. The sauropods may have been more or less omnivorous.*

Fossilized stomach contents of animals are rare and much less common than coprolites or fossilized excrement. Stomach contents old enough to have petrified have been found in connection with marine carnivores—icthyosaurs, plesiosaurs, mosasaurs, marine crocidiles, and fish. Contents consist of hard parts such as bones, teeth and scales of fish, shells of ammonites, guards of belemnites, and hooks of squids. In most cases the ribs enclosing the remains have prevented scattering of the stomach contents.

A fossil specimen found in the late Jurassic Morrison formation of Emery County, Utah, almost certainly represents contents of the stomach or "gizzard" of a sauropod dinosaur, a nonmarine animal.

The specimen was found by Paul Shrum of Kanab, Utah, on the northwest side of a prominent butte in the southeast corner of Sec. 4, T23S, R7E, Emery County, Utah. Geologically, the site is in the Brushy Basin member of the Morrison formation.

When collected the weight was 40 kg, and the shape may be described as flattened ovoid. Since there has been some spalling and weathering of the mass, the original size and shape are unknown.

The rock is a partly silicified limestone in which recognizable fossil fragments make up at least half the total. The fossils are mostly silicified, but the matrix is only partly so. A few spots represent cavities, perhaps originally filled with gas, that are now lined or filled with crystalline material. Here and there are small rounded pebbles of amorphous siliceous material that may have been ingested as lumps of clay.

On the weathered exterior of the fossil the harder silicified wood fragments appear in relief over much of the specimen. Figure 1 is a cut and polished surface showing well-defined sections of the unoriented plant fragments within the structureless matrix of uncertain origin.

The fossil fragments are chiefly vegetal in origin and clearly represent sections of twigs and branches averaging about 2.5 cm long and 1 cm in diameter. There are no leaves, no large pieces, and no carbonized residues. Much of amorphous matrix may be replaced and unrecognizable plant material. The fragments are practically unoriented, fragmented, shredded, and vaguely stratified in one plane. They are unlike the woody fragments commonly seen in the fluvial sediments of the Salt Wash member of the Morrison in which the fragments are water-worn, rounded, carbonized, and mostly well stratified. No sand or fine clastic grains can be seen in this mass, which argues against the plant fragments having been transported and accumulated by running water.

Minor but significant fragments of bone and at least one tooth are visible on the cut surfaces. Very dense as well as very cellular bone fragments are seen. The largest is about 2.5 cm long; most are mere shreds only a few millimeters across. The cellular pieces are

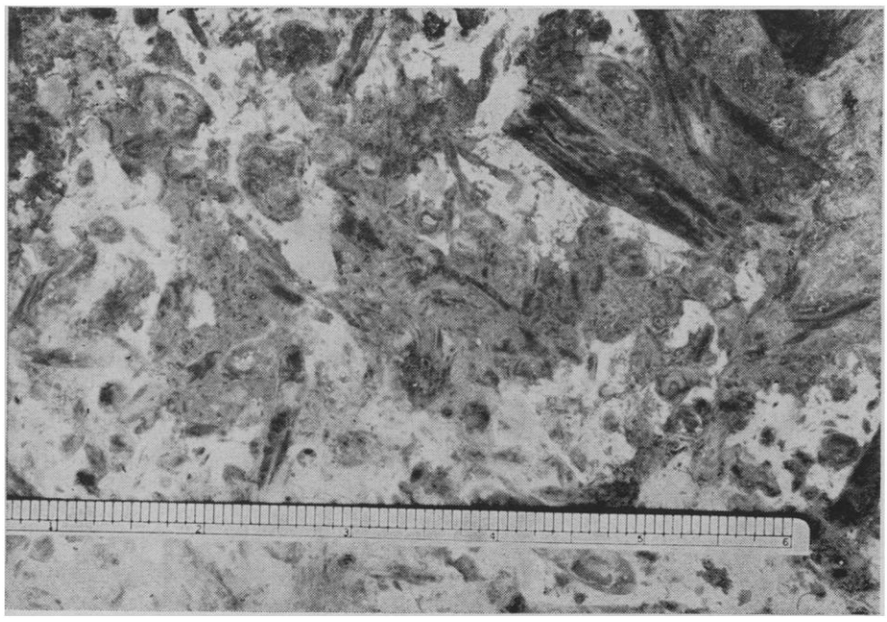

Fig. 1. Cut and polished surface of petrified stomach contents showing unoriented plant fossils, amorphous matrix, and rounded silicified pebbles. Scale in inches.