Although note 24 (page 21) of the article in question involves comparatively few incorrect assertions it contains one which is so extremely bad that the note as a whole is perhaps even worse than the note 18 to which we have referred. In the former it is stated that the sexagesimal system of the ancient Babylonian astronomers involved 59 different numerical symbols. This would correspond to the 9 different digits in our decimal system, but there is no historical evidence that such a complex early system ever existed. It is now well known that the ancient Babylonian sexagesimal system was partly based on the number 10 and that the numbers up to 60 were represented with respect to this smaller base.[2]

It is not implied that all the historical notes in the widely used encyclopedia noted in the opening sentence of this article are in need of radical revision. On the contrary, the majority of them are still reliable, especially those which relate to the more advanced parts of our subject. It may, however, be of interest that some of these notes which relate to the most elementary parts of our subject should now be used with great caution, since historical progress during the last decade or two has been especially rapid with respect to school mathematics, where it might have been least expected. In particular, the history of negative numbers as it is presented in some of our general histories of mathematics is very misleading notwithstanding the fundamental rôle of these numbers in various developments relating to school mathematics. It is questionable whether in any other large field of mathematics the progress during the last forty years has been more profound than in its history.

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MEDITERRANEAN SEDIMENTS AND PLEISTOCENE SEA LEVELS[1]

THE magnitude of the sea level changes during the glacial stages of the Pleistocene are of interest not alone for their bearing on the origin of submarine canyons but also, among other things, for their effect on migrations of animals and plants. Antevs[2] and Daly[3] have independently suggested that the sea level was lowered 80 to 90 meters during the last glacial stage, whereas Shepard[4] has suggested that it was lowered perhaps as much as 900 meters.

An independent test of the hypothesis that sea level was lowered several hundred meters would probably be furnished by a study of the sediments in the western deep basin of the Mediterranean Sea. Long cores of these sediments, like the cores that Dr. C. S. Piggot obtained in 1936 from the North Atlantic, would probably make available the sedimentary record of post-Pleistocene time and part of the last glacial epoch.[5] Such records should be conclusive on the question of great lowering of ocean level because the unusual configuration of the Mediterranean Sea floor and the geographic setting make the hydrography not only peculiar but also sensitive to changes of ocean level and of climate.

Lowering the ocean level about 320 meters or more would profoundly alter the hydrography, and this would be reflected in the deep basins by the formation of varved sediment moderately rich in organic matter like that now forming in the Black Sea.

Lowering the ocean level considerably less than 320 meters, say 80 or 90 meters, would not give rise to varved sediment in the western of the two deep basins, though the glacial climate alone would probably give rise to varves in the eastern deep basin.

Lowering the ocean level 80 or 90 meters would affect the regimen of sedimentation less decisively, yet it seems that the effect should nevertheless be distinguishable, as is outlined below.

In order to show how these conclusions are reached it will be necessary to consider the present hydrography of the Mediterranean and the probable hydrography that existed during the last glacial stage when both the climate and the ocean level were different. A high sill at the Strait of Gibraltar separates the Mediterranean from the Atlantic and a comparable sill at the Sicily Straits divides the Mediterranean into two deep basins (Fig. 1). Over the crest of the sill at Gibraltar the deepest water is approximately 320 meters. In the Sicily Straits the deepest channel across the crest of the sill is 450 meters. These constrictions in the longitudinal profile have a significant bearing on the hydrography.

At present the Mediterranean Sea loses more water by evaporation than it receives from its tributary streams and from the overflow of the Black Sea. In consequence its level is maintained by influx of sea water from the Atlantic. The loss of water by evaporation is greatest in the eastern Mediterranean, so that the Atlantic water, with salinity of about 36 parts per thousand, drifting eastward becomes progressively more saline until near the Syrian coast it reaches a

[2] *Cf.* O. Neugebauer, "Vorlesungen über Geschichte der Antiken Mathematischen Wissenschaften," Volume 1, page 4, 1934.

[1] Published with the permission of the Director, Geological Survey, U. S. Department of the Interior.

[2] E. Antevs, *Amer. Geog. Soc. Research Ser.*, No. 17, p. 81, 1928.

[3] R. A. Daly, *Bull. Geol. Soc. Amer.*, 40: 724–725, 1929.

[4] F. P. Shepard, SCIENCE, 83: 484, May 22, 1936.

[5] C. S. Piggot, *Bul. Geol. Soc. Amer.*, 47: 675–684, 1936; W. H. Bradley, M. N. Bramlette, J. A. Cushman and others, *Am. Geophys. Union Trans.*, eighteenth annual meeting, pp. 224–226, 1937.

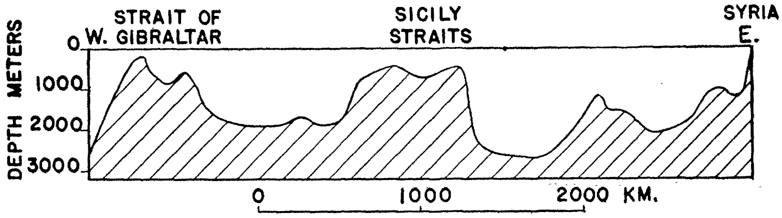

FIG. 1. Profile of greatest depth along the Mediterranean Sea.

salinity of about 39 parts per thousand and becomes so dense that, despite its increased temperature, it sinks to the bottom. This warm, heavy water then moves westward through the deeper parts of the Mediterranean, flows over the sill at Gibraltar, and thence flows down the continental slope till it reaches water of its own density (less saline but colder), where it spreads out in a great fan and eventually mixes with the ocean water. This slow circulation keeps the deep parts of the Mediterranean partly oxygenated, though in the western deep the supply of oxygen is small and the water contains a considerable percentage of carbon dioxide.[6]

Let us consider first what effect the climate of the last glacial stage had upon the hydrography of the Mediterranean Sea. According to Brooks[7] and according to the evidence from many sources assembled by Antevs[8] the climate was cooler and considerably more rainy than to-day. A greater volume of water would therefore have reached the Mediterranean from the increased rainfall and apparently also from the outlet of the Black and Caspian Seas because the Caspian, which then connected with the Black Sea, was receiving overflow from the Baltic and the Arctic.[9] Even under the present climate the Black Sea overflows, hence it seems safe to infer that this greater supply of water, together with the lessened evaporation rate consequent upon the cooler, stormier climate of the last glacial stage, would have caused the Mediterranean to overflow through the straits of Gibraltar. With enough fresh water entering to overbalance the loss by evaporation and cause overflow the hydrography should be analogous to that in the Norwegian fjords described by Strøm.[10] In those fjords a layer of fresh water floods the surface and protects the underlying deep body of salt water from the effect of the wind. Like the Mediterranean these fjords have a high sill at the seaward end. In many this sill is so high that there is room only for the stream of fresh water to pass over it. Thus the salt water in the fjord is sealed beneath a blanket where it becomes stagnant and ultimately charged with hydrogen sulfide. This sort of water stratification is stable and, curiously enough, more persistent the more fresh water flows across the surface of the dense saline water.[11] But in other fjords the sill is not so high and by reason of storms and abnormally high tides oxygenated and somewhat colder ocean water at least partially checks the outflow, pours over the sill, and mixes with and oxygenates the salt water in the deep part.

From this consideration of the Norwegian fjords we may infer that, even if the ocean level had not been lowered during the last glacial stage, the Mediterranean, because of the different climate, would have had a surface layer of essentially fresh water overlying the oceanic water that filled the deep basins. Furthermore, the oxygenated Atlantic water would have had free access to the western basin of the Mediterranean through the Straits of Gibraltar beneath the outflowing surface stream of fresh water and in consequence the deep water of the western basin would have continued to be at least partially supplied with oxygen. But with a blanket of essentially fresh water covering the Mediterranean and moving westward there appears to be no way in which significantly large volumes of the oxygen-bearing saline water in the western basin could move across the sill at the Sicily Straits so as to cause circulation and afford an oxygen supply in the deep saline water of the eastern basin. For this reason the water in the eastern deep basin probably would have become stagnant and depleted of oxygen soon after the climatic change permitted fresh water to flood the surface of the Mediterranean.

Now the stagnation engendered in the eastern basin by climatic change alone would have left an unmistakable record in the sediments that accumulated there. Under these conditions the stagnant water becomes poisoned with hydrogen sulfide, which kills off all the bottom fauna. With no bottom dwelling organisms to disturb the sediment and aid in the destruction of the organic matter the sediment accumulates as successive pairs of thin laminae, one of which is rich in

[6] For a full discussion of the Mediterranean hydrography see G. Schott, *Ann. Hydrographie und Maritimen Meteorologie,* 43 Jahrg., Heft 1: 1–18, 1915, and also *Jour. du Conseil,* 3: no. 1, pp. 139–174, 1928.

[7] C. E. P. Brooks, "Climate through the Ages," p. 315, 1926.

[8] E. Antevs, *Amer. Geog. Soc. Research Ses.,* No. 17, pp. 34–39, 1928.

[9] S. Eckman, "Tiergeographie des Meeres," pp. 141–142, 1935.

[10] K. M. Strøm, *Skr. Norske. vidensk. akad.,* Oslo, 1936, No. 7, pp. 7–59.

[11] G. E. Hutchinson, *Trans. Conn. Acad. Arts and Sci.,* 33: 116–127, 1937.

organic matter and represents the annual pulse in the growth of plankton. The other part of the couplet usually consists of mineral particles with less or no organic matter and represents the remainder of the year. In short, varved sediments would have accumulated as they are accumulating to-day in the deep water of the Black Sea,[12] in certain Norwegian fjords,[13] in salt lakes in Crimea,[14] in the lake of Zürich[15] and in the deep, stagnant and lifeless parts of many other lakes and enclosed seas. Thus it appears that the sedimentary record of the eastern basin of the Mediterranean should reflect the marked climatic changes that accompanied the glacial stages of the Pleistocene.

The following consideration of the hydrography of the western basin suggests that its sedimentary record would contain a decisive test of the hypothesis that ocean level was lowered several hundred fathoms during the last glacial epoch. Again the reasoning turns upon analogy with the Norwegian fjords, for, as outlined above, we can assume that the climate alone would have brought about hydrographic conditions in the western basin of the Mediterranean closely analogous with those of certain ventilated or oxygenated fjords discussed by Strøm.[16] If now the level of the ocean were gradually lowered nearly or quite down to the top of the Gibraltar sill the channels across the sills at Gibraltar and the Sicily Straits would be progressively constricted. The eastern basin would be still more effectively sealed, so we need consider it no further. But now the western basin would eventually stagnate and be depleted of oxygen. For some time oxygen-bearing Atlantic water would spill over the Gibraltar sill at high tide or when the wind piled up the water on the ocean side. But when the ocean level reached the level of the Gibraltar sill, 320 meters below present ocean level, or if it sank still lower, then the hydrography of the western basin of the Mediterranean would be like that of the Black Sea to-day. A blanket of essentially fresh water covering the sea, moving westward and overflowing the sill at Gibraltar would seal beneath it the deep body of salt water which, being thus cut off from its supply of oxygen, would become charged with hydrogen sulfide and varves would form in the bottom sediments like those in the eastern basin and like those now forming in the deep, saline, stagnant part of the Black Sea.

Hence it seems to me that organic-rich, non-glacial varves in the deposits of the deep parts of the western basin of the Mediterranean overlain by a considerable thickness (1 to 2 meters?) of limy coccolith and Globigerina ooze would be strong reason for believing that, during the last glacial stage of the Pleistocene, ocean level was lowered about 320 meters or more.

But if sea-level were only lowered 80 or 90 meters during the last glacial stage, as suggested independently by both Antevs[17] and Daly,[18] it seems likely that, although no varves formed, the sediments off the Algerian coast, and perhaps elsewhere along the Mediterranean, should contain legible records of lowered sea level, but the records would be of a different kind. Anderson's[19] interpretation of the Quaternary events along the coast of western Algeria indicate that during the interglacial stages when the sea level rose the valleys slowly filled with generally fine-grained alluvium and that during the glacial stages when the sea level dropped, large volumes of the alluvial deposits were removed from the valleys and carried into the sea. Thus the deposit formed off shore from these streams during the last interglacial stage should be a layer or bed of fine-grained limy mud, rich in pelagic organisms like coccoliths, foraminifera and pteropods —sediments with less clastic material than those forming there to-day. But during that stage when the sea level was falling the sediments formed off this same coast should be distinguishable from those of the interglacial and postglacial stages by their relatively great abundance of clastic material and probably also by different and colder water pelagic organisms.

Because the Mediterranean region is one of volcanic and seismic activity and because the sea itself is rather sensitive to climatic changes the post-Pleistocene history as recorded in the deep water sediments should be unusually legible.

The pelagic fauna of the Mediterranean was presumably quite different at the end of the last glacial stage, by reason of the greater volume of fresh or feebly saline water that flooded its surface. The more or less gradual change from that condition to the present hydrographic condition should be marked in the sediments, especially of the western basin, by the appearance of generally Atlantic types of coccoliths, pteropods and foraminifera which inhabit the surface waters now. Indeed, these forms may have reached a recognizable peak of abundance during the higher sea level of the "climatic optimum."[20] At some level, perhaps corresponding to late Neolithic time, when, according to Sandford and Arkell,[21] northern Egypt

[12] A. D. Archanguelsky, *Bull. Soc. Naturalistes du Moscou*, new ser., 35: 264–281, 1927.

[13] K. M. Strøm, *op. cit.*

[14] B. W. Perfiliev, "Ten Years of Soviet Science," pp. 402–403, Moscow, 1927.

[15] Fr. Nipkow, *Rev. d'Hydrologie*, 4 Année, No. 1/2: 71–120, 1927.

[16] *Op. cit.*, pp. 42–59.

[17] E. Antevs, *Amer. Geog. Soc. Research Ses.*, No. 17, p. 81, 1928.

[18] R. A. Daly, *Bull. Geol. Soc. Amer.*, 40: 724–725, 1929.

[19] R. v. V. Anderson, *Geol. Soc. Amer., Mem.* 4: 363–376, 1936.

[20] C. E. P. Brooks, "Climate through the Ages," pp. 411–414, 1926.

[21] K. S. Sandford and W. J. Arkell, "Paleolithic Man and the Nile-Faiyum Divide," Univ. Chicago Press, vol. 1, p. 68, 1929.

became desert, the wind-blown sand from the region south of the Mediterranean should begin to make its appearance. This wind-blown sand is abundant in the sediments forming to-day in the deep basins of the Mediterranean.[22]

Less vague, however, would be the record left by the activity of explosive volcanoes. A considerable number of these ash falls in the upper part of the post-Pleistocene column of sediments should be correlatable with human history. Earthquakes, too, should have caused submarine mud slumps that threw into suspension much sediment which settled as widespread blankets[23] of distinctive sediment. Such a blanket of sediment should show a gradation in grain size due to the differential settling rates of the constituent particles thus thrown temporarily into suspension.

It seems to me, therefore, that long cores of the sediments in the deep basins of the Mediterranean would probably reveal an extraordinarily rich and varied record in a locality critical not only by reason of the unusual configuration of the basin but also by reason of the wealth of information that is already available from the long historic records, the archeology and the Pleistocene and post-Pleistocene geology.

W. H. Bradley

TYROSINE DETERMINATIONS[1]

The author was recently engaged in a study of egg albumin in which it was necessary to run tyrosine determinations on small quantities of the protein. Since the method of Folin and Marenzi[2] requires 100 milligrams for each determination, and that of Lugg,[3] approximately 50 milligrams of protein, it was decided to use Lugg's method. It is for the purpose of discussing modifications of this method that this paper is presented.

In the method under discussion, that of Lugg, the 50 milligram sample of ovalbumin is hydrolyzed in alkali as recommended by Folin and Marenzi, acidified, centrifuged and a 3 ml aliquot diluted to 5 ml with 5 and 1 normal H_2SO_4 in such proportions that the 5 ml solution will be at a pH of 0.3 (from titration of a separate aliquot using brilliant cresyl blue as an indicator). It is common knowledge that no efficient indicator is available at this pH range and that the glass and quinhydrone electrodes are extremely inaccurate for this determination. In search of a simpler method of bringing the pH of the standard and unknown solutions to the same and required value it was discovered that one could very well utilize the normality of the test solutions with respect to H_2SO_4. When the 5 ml test solution is made 1 normal H_2SO_4 the buffer action of the amino acids in the solution and the repression of the ionization of the strong electrolyte (H_2SO_4), results in a pH of approximately 1. Block[4] states that a pH of 2.5 is also satisfactory. A series of analyses using the modification outlined here resulted in the following values for the per cent. tyrosine in egg albumin:

3.77; 3.83; 3.85; 3.81; 3.77; 3.83; 3.84
Mean 3.81

These values are close to the figures reported in the recent literature. Bernhart[5] reports 3.85 per cent. tyrosine in ovalbumin as determined by the method of Folin and Marenzi.

Further study of Lugg's method disclosed that another step could be modified for convenience. After the 5 ml test solution has been mercurated with a mixture of mercuric sulfate and chloride and made up to 25 ml, Lugg recommends that the sodium nitrite be added within an hour and compared colorimetrically with the standard (Millon reaction), since cloudiness may develop on longer standing and hinder the comparison. The following experiment was performed:

Six samples of egg albumin were treated simultaneously and in an entirely analogous manner according to the above discussed modification. After the solutions were made up to 25 ml, four samples were compared immediately, and the remaining two, twenty-four hours later. The results obtained from the two sets, in per cent. tyrosine present, are outlined below (the samples were previously treated in an oven for 24 hours at 110 C.).

	Analyzed immediately	Analyzed 24 hours later
	3.61	3.75
	3.67	3.68
	3.75	
	3.83	
Mean	3.72 per cent.	3.72 per cent.

These data can be interpreted to indicate that the test solution, diluted to 25 ml, can remain at least 24 hours before it is compared colorimetrically with the standard without any appreciable decrease in value of the tyrosine present.

The author wishes to thank Dr. L. Earle Arnow for his kind guidance in the work behind this paper.

Carl Reiter

[22] K. Andrée, "Geologie des Meeresbodens," p. 263, 1920.

[23] Fr. Nipkow, *Rev. d'Hydrologie*, 4 Année, No. 1/2: pp. 70–120, 1927.

[1] From the laboratory of Physiological Chemistry, University of Minnesota, Minneapolis.

[2] O. Folin and A. D. Marenzi, *Jour. Biol. Chem.*, 83: 89, 1929.

[3] J. W. H. Lugg, *Biochem. Jour.*, 31: 1422, 1937.

[4] R. J. Block, "The Determination of the Amino Acids," Burgess, Minneapolis, Minnesota, page 21, 1938.

[5] F. Bernhart, Unpublished Ph.D. thesis, University of Minnesota, 1938.