graduation knew about man one must take into account the tradition of education in the classics at that time which was to give attention to the life and ideas of ancient times—the reading of Thucydides was not just an exercise in the Greek language or literature but one in the interpretation of history.

The situation of the social subjects in the colleges to-day is very different. There are numerous courses and a large staff. The increase in the time given by undergraduates to the social studies has been very great, until at the present time the concentration in these fields amounts in some colleges to about one half of the whole. There is great attention to current and recent problems whereas as of my father's time there seems to have been relatively little. That those of our students who concentrate to-day in the social fields learn far more of their detail than students learned seventy-five years ago is certain, but it seems equally certain that those who concentrate in other fields by the very intensity of their concentration may have a far less philosophic outlook upon society than did all the students of those days. What the place of the social studies is or should be in present collegiate education I am not prepared at this time to discuss; were I to discuss it I should probably make some plea for a greater attention to law, education, public health, and possibly administration difficult though that subject is, than is usually accorded to them in such discussions. Furthermore, no matter how much I would emphasize the necessity for professionals to lay more stress on the strictly scientific aspects of social science or however much I might urge that even the collegian might be shown what is definitely known, I should be likely to suggest that where so little is known it would be well to consider the social sciences not as individual branches of learning but as an interest in man, reaching out even to theology as they did at Yale—for who shall assert that man lives by bread alone or that an ideology that triumphs over material conditions does not have to approach to a religion?

ISOSTATIC CONTROL OF FLUCTUATIONS OF SEA LEVEL

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WITH the last retreat of the North American continental ice sheets the northerly drainage of the land was impounded by the ice front at various stages till, with the vanishing of the ice, it finally flowed freely to the ocean. The lakes so formed waxed in size as the ice front receded; but the only escape for their waters was to the south, over cols in the continental divide. There were many of these lakes, large and small, each with its own level of overflow, which remained approximately constant as the lake expanded. The shores of all of them, as they came against the emerging land slope of their respective basins, carved or built shore features, which are in most cases perfectly preserved to this day. At the time of their formation these shore features were of course level, but to-day they are for long stretches inclined to the horizon, up to the north. This inclination of the once level strand lines is due to a tilting of the surface of the earth, and affords an angular measure of the tilt, which is usually expressed in inches or feet per mile. The constant display of tilt up to the north, on the periphery of basins vacated by continental ice sheets to form lakes, has suggested to geologists that the rise is due to relief of load, consequent on the vanishing of the ice and the complete or partial draining of the lakes. This belief is now very generally held. It means that geologists have accepted the view that the earth's crust may be depressed by a local load upon its surface, and recover from the depression when the load is removed. That is, they have accepted isostasy as a valid doctrine. The phenomena of regularly titlted shore lines are perhaps the most impressive and convincing proof of the truth of that doctrine.

Isostasy means equality of mass, per unit of horizontal cross section, in all large vertical columns of the earth. The imposition in the Pleistocene of a broad load of ice, let us say one kilometer thick, upon a portion of the earth's surface threw the column carrying that load out of balance with the rest of the earth. The ice mass came from the ocean; and the column, the top of which is the sea surface, lost load, and was thus also thrown out of balance with the rest of the earth. The unglaciated portions of the continents were neither loaded nor relieved of load, but in glacial time they were nevertheless also temporarily out of balance with both glaciated and oceanic regions, in different degree. The whole disturbance was caused primarily by the transfer of load from the ocean to the glaciated region. If a load equivalent to that of the ice had been shifted in depth from below the ice to the region below the ocean, with uniform distribution as to both removal and addition, balance would have been restored over the whole earth. Since the gravitative tendency to restore isostatic balance, however disturbed, is always active, it is presumed that continental glaciation actually induced the shift of mass in depth from the loaded continental column to the unloaded oceanic column. The volume of the rock mass, thus removed in depth from the glaciated continental column, was less than that of the ice since its density is greater. Volume may be spoken of in terms of thickness, the layers we have to deal with being uniformly thick. Thus the thickness of 1 km of ice of density .917 added to the surface would be compensated by the removal in depth of .278 km of rock of density 3.3 and its distribution to other columns of less mass.

The compensating movement would have set in long before the full accumulation of the ice load, and it would at first have been directed toward both the ocean and the unglaciated portions of the continents. But as compensation for the full load advanced toward completion, the shift of mass in depth would have been from the continents as a whole to the oceanic column, till world-wide balance was re-established. At this stage, assuming that the full ice load continued for a time, the sea level, as compared with its pre-glacial position, would have been lower by the thickness of the layer of water removed to form the glaciers, less the rise of the sea bottom due to the invasion of the column in depth by heavy rock for compensation.

At this stage of universal balance, the surface of the unglaciated continental column would have had the same position, with reference to the center of the earth, that it had in pre-glacial time. The surface of the glaciated column would have been higher and, as already stated, the surface of the oceanic column lower. The mass added to the oceanic column would have been distributed over its entire area, as was the water that went to form the ice sheets. It is difficult to imagine any method of distribution of rock mass from the continental columns to the oceanic column other than plastic flow. The transfer of mass does not imply that the same rock taken from the continental column was delivered to the oceanic column, but only that equality of mass in the two columns was re-established by plastic adjustment.

The problem of how plastic shift of mass in depth, induced by shift of load at the surface, affects the level of the ocean involves the use of data which are not yet fully or certainly determined. Thus the density of the heavy rock, which in depth compensates the oceanic column for loss or gain of sea water, is but vaguely known. Its specific gravity is at least 3.3, and this value is used in the calculations which follow. The arithmetical value arrived at for the fluctuation of sea level lacks precision, but that the fluctuation is real and is isostatically controlled can scarcely be questioned.

An approximation to the mean thickness of the Pleistocene ice sheets at their maximum may be obtained by considering the Greenland sheet of to-day. Lauge Koch gives us a map[1] of Greenland with a few contours on the surface of the ice. The average gradient of this surface, measured on six different lines between the 3,000 m and the 2,000 m contours, is 1 in 459. But the ice front except in the fjords moves very slowly, if at all, and Coleman[2] cites Koch to the effect that it is about stationary.

The Labrador ice sheet flowed from its center of dispersion to and beyond the mouth of the Hudson River. H. L. Fairchild[3] places the maximum post-glacial uplift at Lat. 50°, Long. 75°. But A. P. Low[4] located the center of dispersion of the ice between Lat. 53° and 55°. A probable position for the center is thus Lat. 54°, Long. 75°. The distance from this point to the mouth of the Hudson River is 1,500 km. The present altitude of this center is not precisely known. But Low gives the altitude of Lake Mistassini as 1,300 feet. The mean altitude of the region around the lake is about 300 feet[5] above its surface. This gives us 1,600 feet or about .5 km above present sea level.

When the front of the Labrador sheet, in the wane of the latter, withdrew from the ocean at the mouth of the Hudson River, it occupied a succession of positions in its retreat, at each of which waste just balanced the forward flow of the ice. One of these positions was the present shore line at New York. Then, considering the front as stationary for a brief time, the gradient of the surface of the ice was probably about the same as that of the Greenland sheet to-day, 1:459. Then the ice surface at the center of dispersion would have been $\frac{1}{459} \times 1{,}500 = 3.27$ km higher than at the front. We may suppose that at this stage the surface of the Labrador sheet at its front was .3 km above present sea level, and that at this, or any other stage of the early retreat, the thickness of the ice at the front was also .3 km. Then the center of dispersion was $3.27 + .3 = 3.57$ km above the contour of the present shore. The load of ice isostatically displaced an equal mass of heavy rock in depth, having a specific gravity assumed to be 3.3; and there was a depression of the region corresponding to the thickness of the heavy rock displaced. If x be the thickness of the ice at the center of dispersion, $x = 3.57 - .5 + \frac{.917x}{3.3}$, whence $x = 4.3$ km; and the mean thickness of the ice from the center of dispersion to the mouth of the Hudson River was about $\frac{4.4 + .3}{2} = 2.35$ km.

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[1] *Jour. Geol.*, 31: 48, 1923. Reproduced by Coleman in his "Ice Ages Recent and Ancient," p. 29, 1926.

[2] *Op. cit.*, p. 28.

[3] *Bull. Geol. Soc. Amer.*, 29: 187–234, 1918.

[4] *Geol. Survey Can. Ann. Rpt.*, viii, p. 387 L., 1897.

[5] A. P. Low, *op. cit.*, p. 68 L.

But this thickness is that of a sheet having the same gradient as the Greenland sheet, or 1:459; and the front of the Greenland sheet is stationary. For maximum vigor of both Greenland and Labrador sheets, the supposition may be made that the mean thickness was 50 per cent. greater than that which corresponds to a gradient of 1:459. On this assumption the Labrador sheet at its maximum would have had a mean thickness of $2.35 \times 1.5 = 3.52$ km. If now, for the maximum vigor of the Labrador sheet, x be the thickness of ice at the center of dispersion and .3 km be taken as the thickness at the front, out in the Atlantic, then the mean thickness is $\frac{x + .3}{2}$. Thus, $\frac{x + .3}{2} = 3.52$, whence $x = 6.74$ km. For this load the isostatic depression was $\frac{6.74 \times .917}{3.3} = 1.87$ km; and the altitude of the ice surface at the center of dispersion was $6.74 + .5 - 2.04 = 5.2$ km. The gradient of the Labrador sheet at this maximum stage depends on how far the front had advanced beyond the line of the present shore.

If the mean thickness of the Labrador sheet at its maximum be assumed to have been 3.52 km, we may, to extend the discussion, adopt this figure for the mean thickness of all continental ice sheets at the height of pleistocene glaciation. Coleman[6] gives the area covered by continental ice in Pleistocene time as 12,000,000 square miles or 31,000,000 square kilometers. The volume of this ice is $31{,}000{,}000 \times 3.52 = 109{,}120{,}000$ cubic kilometers. To supply this ice a layer of water $\frac{109.12 \times .917}{368} = .27$ km thick was removed from the ocean, the extent of the ocean being 368,000,000 sq. km and the expansion of water on freezing $\frac{1}{12}$. The removal of this load of water would have necessitated the addition in depth of a layer of heavy rock, of specific gravity, say 3.3, for isostatic compensation. This layer of rock added to the oceanic column would have had a thickness of $\frac{.27}{3.3} = .08$ km, and would have raised the sea bottom that much. The net fall of sea level, relatively to the center of the earth, or to the pre-glacial sea level, was $.27 - .08 = .19$ km. The layer of rock added to the oceanic column had the same mass and the same volume as that forced out of the continental columns to compensate the load of ice.

Of the total area (31,000,000 sq. km) covered by ice sheets in the Pleistocene one half has been completely deglaciated, and the ice still remaining on the other half, comprising Antarctica and Greenland, has been reduced in thickness. The reduction may be again taken, for the purposes of this discussion, at about one third of the maximum. That is, the mean thickness of existing ice sheets, covering an area of 15,500,000 sq. km, is supposed to be 2.35 km instead of the 3.52 km at maximum glaciation. The total volume of ice thus restored to the ocean since the maximum Pleistocene glaciation is about 72,740,000 cu. km. As water spread over the ocean it is a layer $\frac{72.74 \times .917}{368} = .18$ km thick; and if no other movement occurred the sea level would be raised that much. But this load of .18 km of water has been, or is in process of being, compensated by the removal from the oceanic column in depth of a layer of heavy rock. The thickness of this layer, at the assumed density of 3.3, is $\frac{.18}{3.3} = .05$ km; and the sea bottom would subside that much. Thus the net rise of sea level due to the waning and partial melting of the Pleistocene ice sheets, up to the present, is $.18 - .05 = .13$ km. For the total rise of sea level in this time we must of course add the effect due to the delivery to the ocean of the products of ordinary stream erosion.

OBITUARY

LEE CLEVELAND CORBETT

THE death of Dr. Lee Cleveland Corbett, which occurred on July 13, 1940, at his home in Takoma Park, D. C., came as a surprise to most of his friends. Though it was known following his return on the first of April from Florida that he was not well, few realized that his condition was critical.

The principal steps of Dr. Corbett's professional career after graduating from Cornell University, College of Agriculture, in 1890, constitute a continuous progression. From 1891–3 he was assistant horticulturist at the Cornell University Experiment Station under Dr. L. H. Bailey. In 1893 he went to South Dakota in the pioneer period of agricultural education there, as professor of horticulture and forestry in the State Agricultural College and Experiment Station, where he remained two years, going in 1895 to the University of West Virginia as horticulturist, where he continued until April, 1901, when he was appointed as horticulturist in the U. S. Department of Agriculture.

By a then recent Act of Congress, the tract of land across the Potomac River from Washington to become known later as Arlington Farm, had been turned over to the Department of Agriculture. Dr. Corbett's chief assignment, and his principal activity for several years, was the development of this land for experimental

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[6] *Op. cit.*, p. 9.