ing extra locomotives and coal, and causing much confusion. Therefore, in my opinion it behooves every patriotic and unselfish member to consider very seriously whether he can really serve his country by attending the meeting, or whether he can not better serve in this fateful time by staying at home, especially during a period of highly congested travel, when many of our soldiers may wish to take leave of their families before departing for the front. I believe that only those persons bringing really important contributions to the problems of the war should attend such meetings now. All others, in my opinion, should conserve their money for Liberty bonds and for those in distress, and should save their strength for action in this time of extraordinary crisis. For these reasons, with great regret, I have decided not to attend the meeting at Pittsburgh.

So far as I have been able to ascertain, all the responsible authorities at Washington concerned with transportation agree with me as to the importance of avoiding unnecessary journeys in such a crisis.

The very great usefulness of the American Association for the Advancement of Science is not dependent upon the unbroken continuity of its social meetings.

Science is incalculably important, indeed indispensable, in this world-wide cataclysm. The excellent work of the association in the past is now bearing fruit; but this moment demands action rather than general discussion. We must devote all our energies to winning the war. Let us all make every endeavor to apply our knowledge and strength in our country's noble cause.

THEODORE W. RICHARDS

CAMBRIDGE, MASS.,
December 15, 1917

THE BEARING OF THE FACTS REVEALED BY ANTARCTIC RESEARCH UPON THE PROBLEMS OF THE ICE AGE[1]

RECENT Antarctic explorations and researches have yielded significant evidence regarding the problems of the Ice Age, and, of the similarity of the succession of geological climates in polar with those in other latitudes.[2]

These researches have been prosecuted to the ultimate limit of courage, devotion to duty and endurance—the noble sacrifice of life—as in the cases of Captain Scott, R.N., and his devoted companions and members of the expedition of Sir Ernest Shackleton.

The data secured by these expeditions are alone sufficient to establish the following premises:

1. That Antarctic ice, although covering areas several times larger than all other ice covered areas, is slowly decreasing in extent and depth.

2. That the same succession of geological climates have prevailed in Antarctic as in other latitudes.[3]

So vital are these evidences of the retreat of Antarctic ice that it may be well to briefly quote or refer to the most prominent instances:

> All these evidences and many others which space will not allow me to mention lead up to one great fact—namely, that the glaciation of the Antarctic regions is receding.[4]
>
> The ice is everywhere retreating.[5]
>
> The high level morains decrease in height above the present surface of the ice, the débris being two thousand feet up near the coast and only two hundred feet above near the plateau.
>
> (Scott's lecture on the great ice barrier.[6])

[1] This term as used by the writer refers to the Great Ice Age of Pleistocene Time. He holds that the occurrences of ice as a geologic agent of magnitude during eras preceding the Pleistocene were not "world wide" nor as "phenomenal," nor were they preceded, accompanied nor followed by conditions as significant as corresponding phenomena of the Ice Age. (Compte Rendú du XI ième Congrès Géologique International, p. 1105. Stockholm, 1910.)

[2] "Scott's Last Expedition," Vol. II., p. 206.

[3] This part of the evidence is not considered in this paper except inferentially as bearing upon the general subject.

[4] Scott, "The Voyage of the *Discovery*," Vol. II., page 416. See also pp. 423–24–25, and sketch map of ice distribution, p. 448.

[5] Scott, "National Antarctic Expedition, 1900–1904," Vol. I., p. 94.

[6] "Scott's Last Expedition," Vol. II., p. 294.

This observation applies to an ice-covered area of over 116,000 square miles.

Mr. Griffith Taylor notes the recession of Dry Valley Glacier twenty miles from the sea below Taylor Glacier.[7]

Mr. Taylor also notes and speaks with confidence of the passage of the Ice Age from Antarctica.[8]

In speaking of the evidence of ice retreat over Antarctic areas explored by him, Sir Ernest Shackleton said:

> Some time in the future these lands will be of use to humanity.[9]

This impressive and conclusive evidence is corroborated by the greater and still more impressive evidences of the comparatively recent uncovering of temperate land areas,[10] and the progressive retreat of the snow line to higher elevations in temperate and tropical latitudes and towards the poles at sea level, being far greater in Arctic than in Antarctic regions. We are therefore confronted with the conclusions:

1. That the disappearance of the Ice Age is an active present process and must be accounted for by activities and energies now at work, and that the use of assumptions and hypotheses is not permissible;

2. That the rates and lines of retreat are and have been determined by exposure to solar energy and the temperatures established thereby; and by the difference in the specific heat of the land and water hemispheres;

3. That the lines of the disappearance of ice are not conformable with those of its deposition, and mark a distinctly different exposure and climatic control from that which prevailed prior to the culmination of the Ice Age.

4. This retreat also marks a rise in mean surface temperature along these new lines, manifestly due to recently inaugurated exposure to solar radiation and also the inauguration of the trapping of heat derived from such exposure; which process is cumulative and has a maximum not yet reached.

The researches under the direction of Captain Scott and Sir Ernest Shackleton have therefore very rigidly conditioned any inquiry as to the causes of glacial accumulation and retreat. These conditions are CORRECTIVE and DIRECTIVE—*corrective,* in that they have entirely removed any doubts as to the alternate glaciation of the poles under the alternate occurrence of aphelion and perihelion polar winters by the precession of the equinoxes, as advanced by Croll; *directive,* in that they have imposed an appeal to energies now active as causes of retreat, and divested the problem of resorts to the fascinating but dangerous uses of suppositions and hypotheses.

They have, moreover, pointed out with unerring accuracy the vital conclusion that the same energies which have but recently converted the glacial lake beds of Canada into the most productive grain fields of the world will in time convert the tundras of to-day into the grain fields of to-morrow.[11]

The bearing of this conclusion upon the ultimate development of the human race is so far-reaching in its consequences that the great sacrifice of life attendant upon the prosecution of these researches stands forever as a memorial in the correction of the erroneous and wide spread conception that the earth is in a period of refrigeration, desiccation and decay; and establishes the conclusion that it is in the spring time of a new climatic control during which the areas fitted for man's uses are being extended and that the moss of polar wastes will be replaced by rye and wheat.

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[7] *Ib.*, p. 286.

[8] *Ib.*, p. 288. See also photograph following p. 286 and p. 292.

[9] Address to the Commonwealth Club, San Francisco, Calif., November 7, 1916.

[10] Slight fluctuations in the retreat of the small residual glaciers in temperate latitudes are noted in the reports of the Commission on Glaciers of the International Geological Congress by Professor Harry Fielding Reid. But the great measures of the progressiveness of glacial retreat are in the past disappearance of the Pleistocene ice fields of temperate latitudes and the present retreat in the Antarctic and Arctic regions.

[11] See also Compte Rendú du XIième Congrès Géologique International, p. 1102. Stockholm, 1910.