

of these objects radiating their heat more rapidly than the surrounding air, and because they are solid forms presented to a liquid at the moment of crystallization, the feathers of the hoar frost extending to windward as each particle of water is driven by the breeze and frozen upon it.

So in a stream of water at the freezing-point, the stones at the bottom no doubt radiate their heat more rapidly than the surrounding medium, and particle after particle of water assumes its crystalline form on coming in contact with the solid, thus forming tubular masses in the direction of the stream.

124, WINCHEAP, CANTERBURY.

S. GORDON McDAKIN.

PROF. NORDENSKIÖLD ON RECURRENT GLACIAL PERIODS.

SIR,—Prof. Judd has told us repeatedly of late, not without some flourish of trumpets, how completely Prof. Nordenskiöld has demolished Mr. Croll and his theory of the causes of glacial epochs. Now from my youth up I have been backward in my reading, and have had an unconquerable aversion to books, and never read anything myself, if I can get a kind friend to read it for me, and tell me what it is about. So I have not yet read Prof. Nordenskiöld;<sup>1</sup> Prof. Judd is evidently thoroughly well up in him, and he would be doing a great kindness to myself, and perhaps others who are equally ignorant and lazy, if he would send you a short article giving Prof. Nordenskiöld's facts and arguments. Prof. Judd says these do not support Mr. Croll's theories; but what I especially want to know is, whether there is anything in them that tells against the generally received views on the subject.

YORKSHIRE COLLEGE OF SCIENCE, LEEDS.  
Dec. 9th, 1876.

A. H. GREEN.

GLACIAL ORIGIN OF LAKES.

SIR,—I have to ask for space for a reply to the courteous letters of Mr. Bonney and of my friend Mr. Judd.

Mr. Bonney's letter is mainly explanatory of his position, which several circumstances—unnecessary to detail—combined to render somewhat ambiguous. I think comparison would tend to show that

<sup>1</sup> The paper by Prof. Nordenskiöld especially referred to by Prof. Judd, is "On the Former Climate of the Polar Regions," being an address by Prof. Nordenskiöld delivered at the Anniversary Meeting of the Royal Swedish Academy of Sciences, March 31, 1875, and translated and printed *in full* in the GEOLOGICAL MAGAZINE, 1875, Dec. II. Vol. II. p. 525. The passage quoted by Prof. Judd appears at p. 531, but the whole paper is well worthy of perusal; as is also his paper "On the Geology of Icefjord and Bell Sound, Spitzbergen," GEOLOGICAL MAGAZINE for 1876, pp. 16, 63, 118, 255. Perhaps Prof. Green will "get a kind friend to read them for him." Nordenskiöld's "Expedition to Greenland" also appeared in the GEOL. MAG., 1872, Vol. IX. pp. 289, 355, 409, 449, 516, and has some good materials in it bearing on the former climate and the extinct floras. Many of our readers, when oppressed with the wearisome effort to master the contents of our monthly issue, will cordially sympathize with Prof. Green, and wish for a mental digester and Assimilator (like the Artificial Stomach in the Loan Collection) into which, as into a "Papin's Digester," they might put their heavy reading, and so get therefrom the *extractum sensorum* in a concentrated form. Till this invention is patented, Prof. Green has hit upon a happy expedient: "Get a kind friend to tell you what it is about"!—EDIT. GEOL. MAG.

we occupy not unlike grounds. Mr. Bonney admits some tarns, like Grasmere, as glacial; admits, hesitatingly, in part if not wholly, some lakelets, (do these include Grasmere's neighbours?); admits that once a basin is formed, a glacier works in it "under very favourable conditions" (Letter to Mr. Fisher, p. 377), thus granting to the process *increasingly* favourable conditions; but demurs to the statement "that though competent to deepen a lake-basin, a glacier could originate it." It would thus seem to be with Mr. Bonney a question, not of ability, but of *time*." Did the glacial period last long enough to enlarge, under "very favourable conditions," a tarn it was able to originate under *less* favourable conditions.

If I understand Mr. Bonney correctly, we are at one both in our desire to bring each case to the test of observation, and in our appreciation of the increase of theoretical probability as the series advances from tarn to lake. But if the utmost that even his careful observations can do for him is to render the glacial theory probable or improbable (p. 376), then surely these theoretical probabilities are worthy of greater weight than he gives them. His illustrations of blown sand eroding (must we say *tarns*?), and Homeric youths spreading erratics, seem to me scarcely relevant to the state of the question.

The latter paragraphs of Mr. Bonney's letter call for no remark from me, as they involve—at this stage—a knowledge of the Alpine lakes that I do not possess. I may assure Mr. Bonney, however, that though I have ventured to remark on his theories, I do not question his facts.

The letter of my friend Mr. Judd I must attempt—with much diffidence in my own powers—to answer, for it involves destruction to my position. First, let me say a word of explanation. In supposing me prepared "to admit the overwhelming probabilities" of the subsidence theory in regard to all the larger lakes, Mr. Judd misunderstands me. *A priori* probabilities in relation to lakes both large and small, I believe must be conceded to *both* theories. But in such questions, *overwhelming* probability can be allowed only to overwhelming proof.

In the second place, as regards the halting-place that Mr. Judd finds between tarns and lakes. If, as I argued, a glacier is a tool that greatly grows in calibre and efficiency as a tarn-hollow enlarges,—that scrapes harder and scores deeper, then to concede tarns to the feebler tool and deny them enlargement by the more powerful, nothing being pointed to as intervening to stop the action, is what may very properly be characterized as not logical and not reasonable. Nevertheless, as for want of standing room and a fulcrum, Archimedes found his theoretically infinitely powerful tool limited by "reasonable proportions"—the limit of all terrestrial tools, so are "reasonable proportions" the limits also of glaciers and their work. While caution then compelled me to remember, and to indicate in my paper, that there *are* limits to the enlargement of tarns by glaciers, that fact—even in Mr. Judd's able hands—leaves the tarn and lake question precisely on its former basis.

My friend suggests to me, however, an analogy which may help

it on, and aid me to show the fallacy of the analogy by which he seeks to undermine some of the grounds I occupy. Every one who has studied streams and rivers knows that below rapids and falls, and at other places, they scoop pools much deeper, and also broader, than the average stream near the place. The little runnel makes a rough dimple; the Highland burn a linn; the alluvial river leaves in its old channels small meres; and in the valley of the great Amazon these isolated pools are represented by lakelets or lakes some ten miles long, roughly speaking, and thirty or forty feet deep. The rule is, that *the volume of the stream determines the size and the contents by volume of the pools it makes*. Glancing back now to the question of "reasonable proportions," it is evident that this rule must not be unreasonably stretched by a use of blind logic. To say that it applies within reasonable limits, is correct; to say that any one allowing only the pools of the burn to the large river is illogical (as well as *wrong*) is also correct. But to repudiate the rule because it cannot explain lakes proportioned by their size to the hypothetical pools of impossible rivers, would be simply futile.

But I proceed to apply this rule elsewhere. Mr. Judd refuses to allow that a glacier grinds in a basin with added force, on the grounds that "we are led to infer" that streams of water and rivers of ice fall under similar laws of motion (p. 525), and in a preceding paragraph (p. 524) he says what must involve belief on his part, in the production by glaciers of basins proportional in superficies to the pools of the Highland burn and Mississippi river. The above rule, that streams of water make their pools according to their volume, being correct, rivers of ice, Mr. Judd will probably admit, should do likewise. Now streams very much broader than the Amazon do not, and probably could not exist, though I am safe in saying that if they did their pools would be *lakes*. But it is a truism now-a-days that glaciers many times wider than the Amazon did and do exist. The Humboldt glacier is about 60 miles wide; ancient glaciers moved over plateaux and over-rode watersheds, and by the analogy claimed by Mr. Judd we would be justified—nay, encouraged—in predicating as possible lakes limited in breadth only by the volume of glacier and ice-sheet. It is not immoderate then to ask for the sprinkling of tarns and lakes which the nature of the pre-glacial surfaces favoured.

Although, as I think, legitimately damaging to Mr. Judd's position, his parallel between ice and water cannot strictly be carried out. The cascade of a Highland burn tumbles into a pool less broad sometimes than deep, and not much longer. To accredit glaciers with such powers were to forget an important element of difference—the greater rigidity of ice. It is this property—the same that makes glaciers habitually scratch rocks as well as smoothing them, thus giving them a greater rock-hollowing power—that has made it possible for me to argue, what could not be argued of water, that the deeper a glacier drives a basin, "the more fully it feels its power and the more easily and rapidly it works."

A word now upon the stratigraphical division of the question. With deference to Mr. Judd's authority, I must say that I cannot agree with him that the horizontality of the Assynt mountains is "an

optical delusion." If the boundary-lines of beds 15 and 20 feet thick can be distinguished separately, local deflections from the horizontal even to that amount should be visible too. Nor is the fact that they are only "nearly horizontal" worthy of any weight. Their dip is about  $1^\circ$  westward. They have been spoken of<sup>1</sup> as "with their strata so little inclined that these can be traced by the eye in long horizontal bars on the side of the steeper declivities." But while holding by what I have affirmed on the subject, I am sensible that Mr. Judd's objections can be obviated only by an authority equal to his own.

WARR-ON-TYNE, Nov. 14th.

HUGH MILLER.

"THE CLIMATE CONTROVERSY."

SIR,—Will you allow me to call the attention of geologists interested in this subject to a statement made by Sir George Nares to the Geographical Society.

He tells us that in the extreme north of Greenland, as well as on the opposite side of Smith's Sound, instead of the land being enveloped in ice like the more southern parts of Greenland, *the glaciers do not reach the sea*. This Sir George attributes to the snowfall being less than the summer sun can dissolve, the snow-bearing clouds discharging their contents principally in latitudes further south, and the land-ice being made up of undissolved snow.

Now does not this militate against the possibility of a polar ice-cap, as well as against the alleged cumulative tendency of snow and ice over any large portion of the polar areas? If with the present lower excentricity the aphelion sun of the northern summer is sufficient to dissolve the winter snow in latitude  $82^\circ$ , would not the perihelion sun of a high excentricity be proportionately more effective, instead, as Mr. Croll contends, of being insufficient to prevent the accumulation of snow? During the augmented cold of the Glacial period would not the region of excessive snowfall have been pushed down to about lat.  $55^\circ$  in Europe (where we find evidences of the enveloping land-ice), and the chief part of Greenland, instead of, as now, being enveloped in ice, have been in the ice-free condition of the land about Smith's Sound? And since the cold of that region, notwithstanding this absence of land-ice, was found to be more intense than that of latitudes where the ice envelops the land, may not the cold of the Glacial period have been proportionately more intense without any greater snow accumulation than now prevails?

SEARLES V. WOOD, JUN.

OBITUARY.

ELKANAH BILLINGS, F.G.S.

BORN 1820, DIED 1876. AGED 56 YEARS.

THE late Mr. Billings was born in the Township of Gloucester, near Ottawa, Ontario, on the 5th of May, 1820. His family came originally from Wales, and settled in the New England States, but subsequently removed to Canada. Mr. Billings was educated partly

<sup>1</sup> Prof. Geikie's *Scenery of Scotland*, p. 211.