served by him in West Somersetshire in 1866, and stated that in 1849 he had himself called attention * to the marks of glacial action shown in the terminal curvatures of slaty rocks in Forfarshire, and suggested that they were to be explained by the progression of a thick covering of ice along the edges of the slaty beds.

DISCUSSION.

Mr. GWYN JEFFREYS read extracts from the Rev. Mr. Hodgson's 'History of Northumberland' (published in 1827), in which these borings in limestone were referred to the action of snails. Mr. Jeffreys considered the foot to be the sole instrument employed by the boring Mollusca in excavating their burrows. He exhibited specimens of Lias from Lyme Regis perforated by *Pholas*, and of hard limestone from Malta perforated by *Lithodomus*, and remarked, in connexion with the notion that asperities on the shell might be boring agents, that the shell of *Lithodomus* is perfectly smooth.

Prof. RAMSAY mentioned that he had seen *Helices* taken out of these holes at Tenby by Dr. Buckland, who believed that the snails effected the perforations by the agency of an acid.

Mr. CHARLESWORTH thought that if so much uncertainty could prevail upon such a subject, it threw great doubt upon some of the grandest generalizations of geology. He referred to the evidence connected with the glaciation of the Great Orme's Head, in which the origin of the perforations under discussion was of much importance, Mr. Darbishire maintaining that they were the work of *Pholades*, while Mr. Bonney asserted that they were produced by snails. In the same way the origin of the celebrated borings in the Temple of Jupiter Serapis might be disputed, and the generalization founded upon it rendered doubtful. Mr. Charlesworth noticed the necessarily small proportion of borers to the whole snail-population of Britain, and remarked especially upon the absence of perforations in the chalk districts. He considered that repeated observations were necessary before this snail-engineering could be admitted, and suggested a systematic course of experiments.

Mr. BOYD DAWKINS suggested that the carbonic acid exhaled by snails in respiration might act upon limestones, and remarked that chalk weathers too rapidly to preserve the excavations.

2. *On the probable Cause, Date, and Duration of the GLACIAL EPOCH of GEOLOGY.* By Lieut.-Col. DRAYSON, R.A., F.R.A.S.

(Communicated by Alfred Tylor, Esq., F.G.S.)

[Abstract.]

AFTER referring to the evidence of the occurrence of a Glacial Epoch, and to the various hypotheses which have been proposed to

* Jameson's Edinburgh Journal, vol. xlv. p. 377.

account for it, the author brought forward the following considerations :—

Of the three principal movements of the earth, namely its daily rotation on its axis, its revolution round the sun, and the slow conical movement of its axis of rotation round the poles of the ecliptic, the third is, in the author's opinion, the cause of glacial epochs. The angular distance of the pole of the ecliptic and the pole of the heavens is at all times the exact measure of the obliquity of the ecliptic, or the extent of the Arctic circle upon the earth. There is evidence that during the last 2000 years these two poles have gradually decreased their angular distance, so that, while the pole of the heavens moves round some curve at the rate of about 1° in seventy-two years, it approaches the pole of the ecliptic at a variable rate, at present about $46''$ in a century. The author had calculated from the recorded positions of the pole of the heavens during the last 2000 years, the curve traced by this pole with relation to the pole of the ecliptic. He found it to be a circle, the centre of which is 6° from the pole of the ecliptic, and $29^{\circ} 25' 47''$ from that of the heavens.

Taking this curve as a guide, the author finds that 2000 years ago the angular distance of the two poles was about 24° , giving a climate scarcely different from that now prevailing. 4000 years ago the angular distance would be about 29° , when the climates of high northern and southern latitudes would present much greater seasonal changes than at present; and these changes would go on increasing back to the year 13,000 B.C., at which period the distance between the two poles would be greatest, namely $35^{\circ} 25' 47''$. This would bring the arctic circle down to latitude $54^{\circ} 35' N.$, that is to a line passing south of Moscow, just north of Berlin, north of Amsterdam, nearly through the middle of Great Britain, and then through Labrador and British Columbia. All the countries north of these places would be subjected to arctic conditions; and these would prevail with even more severity than at present in the winter, whilst from the greater elevation attained by the sun in summer that season would be much hotter than at present, the summer of the lower arctic latitudes being even tropical in its intensity. These extreme changes of climate would prevail, according to the author, during a period of about 15,000 years; that is to say, commencing about 21,000 years ago, the climate would become more and more extreme up to about 15,000 years ago, and then gradually more and more equable to about 6000 years ago.

DISCUSSION.

Prof. RAMSAY inquired whether the author's theory involved the recurrence of glacial epochs, and whether he considered the course of the described phenomena to be constant in early astronomical epochs.

Rev. OSMOND FISHER inquired whether the curve was founded on observed facts, or whether it was obtained from physical considera-

tions. He also asked whether the line representing the change in the direction of the pole formed a reentering curve, and whether the theory would account for the climate of Greenland in Miocene times. He suggested changes in the form of the earth which must have affected the direction of its axis.

The PRESIDENT remarked upon the difficulty that arose from astronomical theories differing so much among themselves. He referred particularly to Adhémar's theory, and remarked that the difficulty connected with it is, that it invokes a recurrent cause, which must produce similar effects every 21,000 years, whilst there is very little evidence of glacial action during the whole long period of the Tertiary epoch.

The AUTHOR, in reply, stated that he could not go back beyond 30,000 years, but that he thought glacial conditions must recur. He had not astronomical data beyond 2500 years; and these were very vague. The motion would be the same in kind, but uncertain in degree. His theory was based entirely upon observed facts. In laying down the curve, he considered it safe to go as far as the semi-circle, as he had observations covering 40° ; but he could not say whether the curve would be a reentering one, although it showed a tendency that way, and would certainly be very nearly so. With regard to the change of climate of Greenland, as evidenced by its Miocene flora, he was not sufficiently versed in botany to pronounce an opinion. He remarked, in conclusion, that the distance of the earth from the sun did not seem to affect the climate of the Southern Hemisphere, and stated that Venus is at present suffering under a most severe glacial epoch.

3. *On ALLOPHANE and an ALLIED MINERAL found at NORTHAMPTON.*

By W. DOUGLAS HERMAN, Esq., Student of the Royal College of Chemistry.

2.

(Communicated by W. W. Smyth, Esq., F.R.S., V.P.G.S.)

THE only English localities at which, to my knowledge, allophane has been shown to occur are the chalk-pits at Charlton, near Woolwich, the Purley downs, near Croydon, and a spot not far from Tavistock, in Devonshire. Dr. Charles Berrill, however, shortly before his death, discovered a mineral much resembling the Charlton allophane in physical properties in a pit opened in the ironstones of the Northampton Sand (beds of Inferior-Oolite age) in the grounds of the Northampton General Lunatic Asylum. It occurs as an amorphous, translucent, somewhat hard and exceedingly brittle mineral, of a yellowish colour inclining to red, and incrusting the surface of a sandstone rock.

The following analyses of a specimen of this mineral presented by Mr. Sharp, of Dallington, to the Museum of Practical Geology fully bear out, I think, its claim to be called allophane. I append, for the sake of comparison, Mr. A. B. Northcote's analysis of a characteristic sample from Charlton.