summer of each hemisphere is in perihelion or in aphelion. This, in consequence of the precession of the equinoxes, will occur at intervals of about 25,000 years. That is to say, if in either hemisphere the summer is now in perihelion, at the end of 12,500 years its summer will be in aphelion, and in 12,500 years more it will be in perihelion again. Mr. Croll maintains that glaciation occurs in the hemisphere where there is perihelion summer and aphelion winter, because of the intense cold of such a winter. I think, on the contrary, that the facts of climate which come under our observation show that winter cold has little or no effect in producing glaciation; and that a cold summer, which leaves the winter snow unmelted, is the most favourable condition for glaciation. Such is the climate of the Antarctic continent now. It is obvious that a summer in aphelion, when the eccentricity of the earth's orbit was many times greater than now, must have been a very cold summer.

This theory of the glacial climate appears perfectly satisfactory. The astronomical cause is known to exist, the geological effects are known to exist, and the effect is that which the cause must necessarily produce.

Even if it were true that a glacial climate prevailed in both hemispheres at the same time, no geological evidence could prove such a fact. No geological evidence could tell whether glacial mounds in Norway and in Patagonia, for instance, were strictly contemporary, or separated in date by an interval of 12,000 years.

Dr. Neumayr appears to retain the old notion that changes of climate may be to some extent due to changes in the position of the earth's poles. I am no mathematician, and cannot speak on such a subject with any authority, but Sir William Thomson believes he has proved that the earth is for all dynamical purposes perfectly solid and rigid; and I should think that the axis of rotation of a perfectly rigid oblate spheroid is unchangeable.

Belfast, July 10. JOSEPH JOHN MURPHY.

The American Meteor.

I RECEIVED the following observations from my son, G. S. Henslow, who witnessed the fall of the meteor referred to lately in NATURE. I forward it, as it may perhaps interest some of the readers of this journal.

"The meteor fell about 5 p.m., and divided in mid-air, part of it falling in Minnesota near a town called Kasota; this portion was not found. The other and larger piece fell near Butt City, Iowa. The two places are about a hundred miles distant. It exploded on reaching the ground into myriads of fragments, a number of which have been picked up and sold at fabulous prices. The State University of Minnesota bought the largest piece. It fell on the open prairie, but broke into such small fragments that the surrounding soil was scarcely disturbed at all. We all saw it fall here at Windom. It illuminated the southern sky, and left a cloud resembling the smoke from the funnel of an engine. On bursting, there was a sound like a sharp peal of thunder." G. HENSLOW.

SPONTANEOUS IGNITION AND EXPLOSIONS IN COAL BUNKERS.

AT the Royal United Service Institution, on Friday, July 4, a paper on this subject was read by Prof. Vivian B. Lewes, Royal Naval College. Rear-Admiral N. Bowden-Smith was in the chair.

The lecturer, after premising that in the fast ocean steamers it is now becoming an event of frequent occurrence for the contents of the bunkers to spontaneously ignite, whilst in the Service such a thing as fire in the bunkers is practically unknown, and an occasional, although fortunately very rare, explosion of gas is the worst trouble which the coal stores of our naval monsters have given rise to, directed attention to the causes which give rise to the so-called "spontaneous ignition of coals," and traced the particular circumstances which tend to increase the tendency to it.

The pyrites or coal brasses present in the coal when exposed to dry air undergo little or no change, but when moisture as well as air is present they absorb oxygen and combine with it, forming sulphates of iron, and the ordinary explanation of the spontaneous ignition of coal is that this process of oxidation causes a rise of temperature in the coal which determines its ignition; this, however, has of late years been much doubted, and it can now be proved that the pyrites when present in ordinary quantities are perfectly incapable of doing more than adding slightly to the general rise of temperature, although when present in very large masses they may increase the tendency of the coal to spontaneous combustion by swelling during oxidation, and causing the coal to crumble, and also by setting free sulphur, which, having a lower melting-point of ignition than coal (482° F., or 250° C.) would lower the temperature at which the mass would catch fire.

The real causes which give rise to heating and ignition in any large accumulation of coal are twofold. First, the absorption of oxygen from the air by the carbon; and secondly, the chemical action set up by the absorbed oxygen with the hydrocarbons of the coal.

The most important point to be noticed is the extraordinary effect which initial temperature has on the rapidity of chemical actions of this kind. At a low temperature, and indeed up to about 100° F. = 38° C., the absorption of oxygen, and consequent chemical action, will go on slowly with practically little or no chance of undue heating taking place, but directly the temperature exceeds 100° F., then, with some classes of coal, ignition is only a question of time and mass.

Although the ignition point of various coals lies above 700° F., yet if many of these coals are powdered, and are placed in perforated zinc cases in masses of 2 lbs. or upwards, and these are kept at a steady temperature of about 250° F. in an oven, ignition will generally follow in a few hours; whilst between this and 150° F. it will take days instead of hours for the same result to follow, and at ordinary English temperatures several thousand tons of coal would have to be stored in a very broken condition before any risk of heating or ignition would ensue. In considering this question with regard to coal bunkers, it must be remembered that, although the considerations which had to be taken note of in the case of coal-laden ships still exist, yet they are considerably modified by the smallness of the amount of coal carried, and by the methods of loading and storage employed.

Liability to spontaneous ignition increases with:—

1. *The increase in the bulk of the cargoes.*—Evidence given before the Royal Commission of 1875 showed that in cargoes for shipments to places beyond Europe the cases reported amount to $\frac{1}{4}$ per cent. in cargoes under 500 tons; in cargoes from 500 to 1000, 1 per cent.; 1000 to 1500, to 3·5 per cent.; 1500 to 2000, to 4·5 per cent.; and over 2000 tons, to no less than 9 per cent. Mass influences this action in two ways:—

(*a*) The larger the cargo, the more non-conducting material will there be between the spot at which heating is taking place and the cooling influence of the outer air.

(*b*) The larger the cargo the greater will be the breaking-down action of the impact of coal coming down the shoot upon the portions first loaded into the ship, and the larger thereby the fresh surface exposed to the action of the air.

2. *The ports to which shipments are made* (26,631 shipments to European ports in 1873, resulting in only ten casualties, whilst 4485 shipments to Asia, Africa, and America gave no less than sixty).—This startling result is due to the length of time the cargo is in the vessel, the absorption and oxidation being a comparatively long action, but a far more active cause is the increase of temperature in the tropics, which converts slow action into a rapid one.

3. *The kind of coal of which the cargo consists* (some coals being especially liable to spontaneous heating and ignition).—There is great diversity of opinion on this

© 1890 Nature Publishing Group

point, but it is pretty generally admitted that cases of heating and ignition are more frequent in coals shipped from east coast ports than in South Wales shipments. So much, however, depends upon the quantity of small coal present, that a well-loaded cargo of any coal would be safer than a cargo of Welsh steam coal in which a quantity of dust had been produced during loading.

4. *The size of the coal* (small coal being much more liable to spontaneous ignition than large.)—This is due to the increase of active absorbent surface exposed to the air, a fact which is verified by the experience of large consumers of coal on land; gas managers recognizing the fact that coal which has been stamped down or shaken down during storage is more liable to heat than if it has been more tenderly handled, the extra breakage causing the extra risk.

5. *Shipping coal rich in pyrites (or brasses) whilst wet.*—The effect of external wetting on coal is to retard at first the absorption of oxygen, and so to check the action; but it also increases the rate of oxidation of the pyrites, and they, when oxidized, swell and split the coal into pieces, and this increases heating due to the exposure of fresh dry surfaces.

6. *Ventilation of the cargo.*—For ventilation to do any good, cool air would have to sweep continuously and freely through every part of the cargo—a condition impossible to attain in coal cargoes—whilst anything short of that only increases the danger—the ordinary methods of ventilation supplying just about the right amount of air to create the maximum amount of heating. The reason of this is clear. A steam coal absorbs about twice its own volume of oxygen, and takes about ten days to do it under favourable conditions, and it is this oxygen which, in the next phase of the action, enters into chemical combination, and causes the serious heating. Ventilation, such as used to be sometimes arranged for by a box shaft along the keelson with Venetian lattice up-shafts, supplies about as much air as is necessary to produce the results which end in spontaneous ignition.

7. *Rise in temperature in steam colliers, due to the introduction of triple-expansion engines and high-pressure boilers.*—The increase in stokehold temperature, due to this, is from 5° to 10° F., and this affects the temperature of the adjacent parts of the vessel.

In the coal bunker, the question of mass, which plays so important a part in a hold laden with coal, is almost entirely eliminated, as 50 to 400 tons would be about the capacity of any ordinary bunker, and the cases of spontaneous ignition in masses of coal less than 500 tons do not amount to more than ¼ per cent. The question of initial temperature, therefore, becomes the one important factor. Bunker fires are almost entirely confined to vessels in which the bunker bulkheads are only separated from the funnel by a narrow air-space, or are in close proximity to the boilers themselves; but where the bunkers are stepped back from the funnel casing and boilers, spontaneous ignition is a great rarity. If coal is kept at a high temperature, even though it be far below its igniting point, ignition is only a question of time, and if the bunker coal next the bulkhead is kept at 120° F., any coal with a tendency to absorb oxygen will run a great chance of igniting within a few days. In order to prevent spontaneous combustion of the coal under these circumstances, all that is necessary is to reduce the temperature of the bulkhead in contact with the coal, as if this is kept at a temperature not exceeding 80° to 90° F., there is little or no fear of the oxidation of the hydrocarbons of the coal proceeding with such rapidity as to cause ignition in such a quantity of coal as can be carried in the bunkers, the iron decks, by subdividing the mass, also helping to reduce any risk. In order to reduce the temperature to the required extent, it would be necessary to make the bulkheads close to any heating surface, such as the funnel casing, double, and the side spaces six inches apart, the inner wall being provided at intervals with water-tight openings, through which the interior space can be coated with protective compositions from time to time. Through this double casing sea-water would be allowed to circulate very slowly, and would effectually prevent any undue rise of temperature, whilst to make the arrangements complete a thermostat should be fixed on the inner plate of each bulkhead, which, if the temperature rose to 100° F., would ring a bell in the captain's room, when the rate of flow of water could be increased until the required fall in temperature took place. Should this arrangement prove impossible from any structural cause, then a rapid current of air forced through the bunkers by means of a fan, or even an up-current formed by a good air-pump ventilator in the crown of the bunker, would go far to keep the temperature within safe limits. If such an arrangement were adopted in the fast liners, bunker fires would become a thing of the past, whilst such an arrangement of double bulkhead and water circulation would also solve the still more important problem of how to keep the magazines on board Her Majesty's ships at a sufficiently low temperature to fit them for the storage of E.X.E. and S.B.C. prism powders, and the still more delicately constituted smokeless powders, none of which could otherwise be kept in the auxiliary magazines of the new programme ships; as for safety they are placed between the boilers, and must, of necessity, reach a temperature far above that which any powder could stand without losing moisture, and in consequence developing far higher strains than the guns should properly be subjected to.

The question of explosions in coal bunkers and in the holds of coal-laden ships is a subject totally distinct from that of spontaneous ignition. During the conversion of woody fibre derived from various forms of vegetation into coal, considerable quantities of a gaseous compound of carbon and hydrogen, called methane, marsh-gas, or light carburetted hydrogen, is evolved, and as the action has been spread over long ages most of this gas has found its way to the surface of the coal seam and has diffused itself through the superincumbent soil and has escaped; but a portion has been occluded (absorbed) in the pores of the coal itself, and some also imprisoned in small cavities and fissures in the coal. Marsh-gas, when pure, is perfectly non-explosive, and burns quietly with a faint luminous flame, producing, as the products of its combustion, carbon dioxide and water vapour, but when mixed with ten times its own volume of air, and a light applied, it explodes with a force equal to about 210 lbs. on the square inch. Another cause which tends to increase the danger of explosion is that if the air is charged with fine coal-dust, less than one per cent. of marsh-gas mixed with it gives an explosive mixture, and also extends the area of explosion. In both colliers and coal bunkers the risk of explosion is greatest during the first ten days after shipment.

Marsh-gas is a non-supporter of combustion, so that the presence of the gas, or a mixture of it with air, if present, is a safeguard against spontaneous ignition; and if the precautions pointed out to prevent ignition were carried out in conjunction with simple precautions against explosion, explosions and fires in coal cargoes and bunkers would soon be a thing of the past.

The lecturer strongly advocated the adoption in the bunkers of all new vessels of the double bulkhead, and water circulation to such portion of the bunkers as impinge upon any unduly heated portion of the hold, and that all bulkheads should be made gas-tight; whilst in bunkers containing not more than 300 to 400 tons of coal, as thorough ventilation as possible should be obtained by fitting water-tight air-pump ventilators in the deck above the surface of the coal, while inlets for as cool air as possible should be provided at the bottom of the bunkers, and, where necessary, air driven in from the

© 1890 Nature Publishing Group

fan. Under no conditions should any but safety-lamps be used in coal holds or bunkers.

A discussion followed, and the proceedings closed with a vote of thanks to the lecturer.

A WINTER EXPEDITION TO THE SONNBLICK.[1]

IT is not often that an Alpinist finds leisure to spend a month in winter at an altitude of 10,154 feet above the level of the sea. It may, therefore, interest the members of the Alpine Club, to have the experiences of one who, though not a member of their Society, yet was fortunate enough to make the unusual ascent, which was chiefly undertaken in the interests of science.

It is well known that since 1886, thanks to the united efforts of the Alpine Club, and of the Imperial Austrian Meteorological Society, and in a special manner to the energy and public spirit of Herr Ignaz Rojacher, there is now a thoroughly equipped Observatory on the highest peak of the Sonnblick. This Observatory has been established with the view of affording to students of natural science, physics, astronomy, and meteorology, the means of making such observations as are only practicable at great heights; and of providing them with accommodation in a part of the building which has been named by the owner "The Study."

In carrying on certain inquiries which are only to be solved on high mountains, I had for this purpose spent a month in the summer of 1881 on the Hoch Obir (6716 feet) in Carinthia, and I determined the first winter after the erection of the Observatory on the Sonnblick still further to resume the investigations in a situation which afforded a clear, cold, winter atmosphere, which was absolutely necessary. I was unfortunately unable to realize my intention the first winter (1887), which was the more to be regretted inasmuch as the winter of 1887, and especially the month of February, was unusually fine, whereas that of 1888 was the severest ever known. The "oldest inhabitant" of those parts had no remembrance of such heavy falls of snow and such dark and stormy weather as we experienced in the February of 1888—the month for which I had made all my arrangements for an expedition to the Sonnblick.

My expedition was undertaken with the following objects:—(1) To investigate the radiation of the earth into space, and the irradiation of the atmosphere upon the earth's surface, in order to ascertain, more accurately than had hitherto been done, the temperature of the aërial envelope of the earth. (2) To investigate the question of the blueness of the sky. (3) To discover whether the sparkle of the stars was altogether due to the lower strata of air. Having had a grant from the Imperial Academy of Sciences in Vienna for the purpose, I succeeded in enlisting the services of Dr. Trabert, a young indefatigable man of science, as assistant, to make simultaneous observations on the Rauris, whilst I observed on the Sonnblick.

We reached Lend on the morning of February 3, where we handed over our seven cases of scientific instruments, and my provisions for a month's sojourn on the Sonnblick, to Herr Rojacher's men, who conveyed the whole on a couple of sledges through Embach to Rauris; we driving to Kitzloch Rauris, where we found Herr Rojacher awaiting us, and, after a tough climb of an hour and a quarter up the mountain pass of Kitzloch, we proceeded by sledge to Rauris.

This first day was perhaps the finest during our stay in the Rauris Mountains; on the next, it began to snow; and it was in a heavy snow-storm that I had to set out for Kolm; and so heavy was it, that it was with the greatest difficulty that Rojachrer and I, in our sledge, followed by the *Rossknecht* with my baggage, were enabled to reach the Bodenhaus. From thence, through the woods, to Kreuzbichl, the snow fell thicker and thicker, and it seemed as if we should never get to our destination. Beyond Kreuzbichl there was no path of any sort, and we had simply to wade through the deep snow for fully an hour, before we reached Kolm, Herr Rojacher's residence (5249 feet). On my arrival, I was just in time to telephone to Rauris that I had reached so far in safety, the telephone communication being immediately thereafter interrupted. That journey from Rauris to Kolm had given me some idea of what a snow-storm in those regions meant. The avalanches caused by the weight of snow, had broken down the telephone wires, completely burying them, and, in one place, carrying them away for a distance of over two kilometres.

The *Rossknecht* had just reached Bodenhaus, but was utterly unable to push on further. It was four days before all my cases could be brought on to Kolm; and then the men had to carry them on their backs. Here was I, cut off from the world, snowed up at Kolm, and with little apparent prospect of getting to the Sonnblick; the snow falling faster and faster for four whole days, without intermission. But I was thankful enough to have reached there, for the valley beneath was laid waste with avalanches, making the roads impassable. However, the five days in which I was blockaded at Kolm were anything but wearisome. I could well have undergone a longer imprisonment with a companion so ingenious and intelligent as Rojacher. He had always some interesting subject to discuss, or new problem to set concerning the Tauern range. What perhaps interested me the most were his descriptions of winter life in this inhospitable altitude—its pleasures and difficulties, and particularly his explanation of the *Lahnen*, the local word for avalanches.

There are two kinds of *Lahnen*, he explained, *Windlahnen* or *Windsbretter* (wind avalanches), and *Jauk* or *Grundlahnen* (ground avalanches). The first belong exclusively to winter; the second to spring. These last are the avalanches of which people who live far out of the reach of avalanches have formed the one and sole idea of their nature and composition, thus confounding the two. They are, however, totally different.

The action of the ground, or *Jauk, lahn*, as its name denotes, is to break away from its base on the ground; and, as its second name denotes, mostly in consequence of warmer temperature, *i.e. Jauk*, south wind. It is composed of a huge mass of melting snow saturated with thaw water, that, restrained by the enormous friction of the earth, carries slowly along with it everything that impedes its course. It is set in motion when the moisture of the thawing ground has sufficiently diminished the earth's friction which has hitherto held it back. It needs no propelling medium; its own weight causes it to slide. The prevailing idea that any small particles of snow set primarily rolling by a bird, or any such unimportant agency, can gradually increase to the dimensions of an avalanche, is a pure fallacy. The rolling is a secondary matter; the primary agent in an avalanche is its sliding. They travel slowly, Rojacher said—that is, there is mostly time for escape on first hearing the roar of the heavy falling mass; with the *Windlahn* is no such hope, as both Rojacher, and all others whom I questioned, assured me.

The *Windlahn* he explained in the following manner. The first falls of winter snow fill up all inequalities of the surface. If it lies for a time, it consolidates and forms an even, slippery surface. More snow falling upon this smooth surface has a tendency, by its own weight, to slide off. This is certain to occur if after a heavy fall of snow the new layer has acquired such weight that its pressure overcomes the slight resistance of the underlying stratum, and any chance obstacles that hold it back. As soon as the top pressure is great enough to start a fissure, the

[1] By Dr. J. M. Pernter, of the Imperial Academy of Sciences in Vienna.

© 1890 Nature Publishing Group