the globe, become objects of the greatest importance in connexion with the atmosphere which surrounds it. Three-fourths of the whole mass of the air is within range of the influence of the highest mountains; one-half of the air and nearly nine-tenths of the vapour are concentrated within about 19,000 feet of the sea-level, a height which hardly exceeds the mean level of the crest of the Himalaya; while one-fourth of the air and one-half of the vapour are found below a height of 8500 feet. Thus, mountains even of moderate magnitude may produce important changes in very large masses of the atmosphere, as regards their movements, their temperature, and their hygrometric state; and especially in those strata that contain the great bulk of the watery vapour, and that have the greatest effect therefore in determining the character of climate.

XXII. *Intelligence and Miscellaneous Articles.*

PHYSICAL CONSIDERATIONS REGARDING THE POSSIBLE AGE OF THE SUN'S HEAT. BY PROFESSOR W. THOMSON*.

THE author prefaced his remarks by drawing attention to some principles previously established. It is a principle of irreversible action in nature, that, "although mechanical energy is indestructible, there is a universal tendency to its dissipation, which produces gradual augmentation and diffusion of heat, cessation of motion, and exhaustion of potential energy, through the material universe." The result of this would be a state of universal rest and death, if the universe were finite and left to obey existing laws. But as no limit is known to the extent of matter, science points rather to an endless progress through an endless space, of action involving the transformation of potential energy through palpable motion into heat, than to a single finite mechanism, running down like a clock and stopping for ever. It is also impossible to conceive either the beginning or the continuance of life without a creating and overruling power. The author's object was to lay before the Section an application of these general views to the discovery of probable limits to the periods of time *past* and *future*, during which the sun can be reckoned on as a source of heat and light. The subject was divided under two heads: 1, on the secular cooling of the sun; 2, on the origin and total amount of the sun's heat.

In the first part it is shown that the sun is probably an incandescent liquid mass radiating away heat without any appreciable compensation by the influx of meteoric matter. The rate at which heat is radiated from the sun has been measured by Herschel and Pouillet independently; and, according to their results, the author estimates that if the mean specific heat of the sun were the same as that of liquid water, his temperature would be lowered by 1°·4 Centigrade annually. In considering what the sun's specific heat may actually be, the author first remarks that there are excellent reasons for believing that his substance is very much like the earth's. For the last eight or nine years, Stokes's principles of solar and stellar chemistry have been taught in the public lectures on natural philosophy in the University of Glasgow; and it has been shown as a first result, that there *certainly is sodium in the sun's atmosphere*. The recent application of these principles in the splendid researches of Bunsen and Kirchhoff (who made an independent discovery of Stokes's theory), has demonstrated with equal certainty that there are iron and manganese, and several of our other known metals in the sun. The specific heat of each of these substances is less than the specific heat of water, which indeed exceeds that of every other known terrestrial solid or liquid. It might therefore at first sight seem probable that the mean specific heat of the sun's whole substance is less, and very certain that it cannot be much greater, than that of water. But thermodynamic reasons, explained in the paper, lead to a very different conclusion, and make it probable that, on account of the enormous pressure which the sun's interior bears, his specific heat is more than ten times, although not more than 10,000 times, that of liquid water. Hence it is probable that the sun cools by as much as 14° C. in some time more than 100 years, but less than 100,000 years.

* Communicated by the author, having been read at the Meeting of the British Association at Manchester, September 1861.

As to the sun's actual temperature at the present time, it is remarked that at his surface it cannot, as we have many reasons for believing, be incomparably higher than temperatures attainable artificially at the earth's surface. Among other reasons, it may be mentioned that he radiates heat from every square foot of his surface at only about 7000 horse-power. Coal burning at the rate of a little less than a pound per two seconds would generate the same amount; and it is estimated (Rankine, 'Prime Movers,' p. 285, edit. 1859) that in the furnaces of locomotive engines, coal burns at from 1 lb. in 30 seconds to 1 lb. in 90 seconds per square foot of grate-bars. Hence heat is radiated from the sun at a rate not more than from fifteen to forty-five times as high as that at which heat is generated on the grate-bars of a locomotive furnace, per equal areas.

The interior temperature of the sun is probably far higher than that at the surface, because conduction can play no sensible part in the transference of heat between the inner and outer portions of his mass, and there must be an approximate *convective* equilibrium of heat throughout the whole; that is to say, the temperatures at different distances from the centre must be approximately those which any portion of the substance, if carried from the centre to the surface, would acquire by expansion without loss or gain of heat.

PART II. *On the Origin and Total Amount of the Sun's Heat.*

The sun being, for reasons referred to above, assumed to be an incandescent liquid now losing heat, the question naturally occurs, how did this heat originate? It is certain that it cannot have existed in the sun through an infinity of past time, because as long as it has so existed it must have been suffering dissipation; and the finiteness of the sun precludes the supposition of an infinite primitive store of heat in his body. The sun must therefore either have been created an active source of heat at some time of not immeasurable antiquity by an overruling decree; or the heat which he has already radiated away, and that which he still possesses, must have been acquired by some natural process following permanently established laws. Without pronouncing the former supposition to be essentially incredible, the author assumes that it may be safely said to be in the highest degree improbable, if, as he believes to be the case, we can show the latter to be not contradictory to known physical laws.

The author then reviews the meteoric theory of solar heat, and shows that, in the form in which it was advocated by Helmholz*, it is adequate, and it is the only theory consistent with natural laws which is adequate to account for the present condition of the sun, and for radiation continued at a very slowly decreasing rate during many millions of years past and future. *But neither this nor any other natural theory can account for solar radiation continuing at anything like the present rate for many hundred millions of years.* The paper concludes as follows:—"It seems therefore, on the whole, most probable that the sun has not illuminated the earth for 100,000,000 years, and almost certain that he has not done so for 500,000,000 years. As for the future, we may say with equal certainty that inhabitants of the earth cannot continue to enjoy the light and heat essential to their life for many million years longer, unless new sources, now unknown to us, are prepared in the great storehouse of Creation."

* Popular Lecture delivered at Königsberg on the occasion of the Kant commemoration, February 1854.

DESCRIPTION OF A NEW MINERAL FROM THE URAL. BY M. RODOSZKOVSKI.

In 1857 I discovered at Nijni-Jagurt a variety of concretionary silicate of zinc, the existence of which, as far as I am aware, was not previously known in the Ural Mountains.

It is in concretionary crusts. The surface is covered with small roughnesses, which, seen under a lens, present the appearance of tolerably lustrous indistinct crystals, which are analogous to zeolite. The colour of these is a light blue, with a tinge of green.

The hardness is 5, the specific gravity 2·707. It is soluble without effervescence in acids, gives off water when calcined; it is infusible before the blowpipe, but becomes opake when submitted to the action of the flame; it dissolves in borax, forming an insoluble glass.

The composition of this silicate of zinc, from my analyses, is—

		Oxygen.	
Silica	26·0	13·507	3
Oxide of calcium	1·55	0·43	3
Oxide of zinc	66·9	13·133	
Water	4·7	4·177	1
Oxide of copper	traces		
Protoxide of iron	traces		

and is represented by the formula

$$3 Zn Si + Aq.$$

This variety of silicate of zinc greatly resembles a variety of concretionary carbonate of zinc which I saw at London in the British Museum under the name *Smithsonite*; but as its composition, its form, and its colour differ from those of ordinary silicate of zinc, I name it *Wagite* in honour of M. Waga, the venerable naturalist of Warsaw.—*Comptes Rendus*, December 9, 1861.

THE
LONDON, EDINBURGH, AND DUBLIN
PHILOSOPHICAL MAGAZINE
AND
JOURNAL OF SCIENCE.

[FOURTH SERIES.]

MARCH 1862.

XXIII. *On the Form and Distribution of the Land-tracts during the Secondary and Tertiary periods respectively; and on the effects upon Animal Life which great changes in Geographical Configuration have probably produced.* By SEARLES V. WOOD, *Jun.**

SECTION 1. Introductory.—SECTION 2. The General Geographical Configuration of the Secondary Period.—SECTION 3. The Changes in the Geographical Configuration which resulted from Post-cretaceous Volcanic Action.—SECTION 4. The Effect produced by the Post-cretaceous Geographical Changes upon the Secondary Fauna.—SECTION 5. The Preservation, at the present day, of isolated Remnants of the Secondary Continents, and of the Secondary Fauna inhabiting them.—SECTION 6. Summary and Conclusion.

SECTION 1.—*Introductory.*

THE attempt to restore in description the outline of the lands and seas of a past geological period, although but in their broadest features, and from that restoration to draw conclusions as to results emanating from changes in the distribution of the continental tracts in succeeding periods, will probably in the present state of our knowledge be, by many at least, deprecated as illusory. The consideration, however, of a few leading principles to be observed in making such an attempt will, I trust, tend to remove from the minds of some such an impression, at least sufficiently so to induce a fair consideration of the views here put forward.

It is obvious that if any tract, large or small, be submerged or elevated by subterranean action, the relative levels of all parts of the tract would, if that tract were raised or depressed by a force exerted equally on every portion, remain the same, however frequently the elevation or depression occurred. Such an elevation or depression is, it is true, dynamically impossible, as all these

* Communicated by the Author.