

a kind of olfactory syndrome or diathesis characteristic of the individual. Owing to fluctuations in the affective judgment of odours due to changes in metabolic conditions, it would seem probable that an olfactory diathesis would have some diagnostic value, especially if linked with an examination of colour preferences.

Although the history of perfumery gives much information with regard to odour preferences among different peoples, experiments on a large scale are desirable in order to correlate affective judgments with other factors, such as pigmentation, endocrine balance, etc. Quite an appreciable amount of work has been done on the question of smell and sex, but there is room for further investigation. The problem of preferences is intimately related to the examination of olfactory associations. When dealing with familiar odours, the percentage of failures to form ascertainable associations is relatively small, according to recent (1924) experiments only about 15 per cent. The fact that olfactory associations are very largely formed unawares, makes their investigation of some practical importance, especially when linked up with olfactory associations occasionally occurring in dreams. An odour constitutes a more effective characterisation of persons, objects, and places than a verbal description, and the absence of a direct vocabulary of olfactory sensations raises difficulties. However, the images called up by odours are so vivid that there would seem to be a case for their occasional employment in the practice of psycho-analysis. Another suggestion is to employ odours to induce certain 'moods' for therapeutic purposes, and perhaps, in time, the ancient use of burned feathers may develop into a system of osmotherapy based on a wide knowledge of olfactory reactions.

Olfactory fatigue has not been mentioned, nor the problem of a classification of odours, nor methods of educating the sense of smell, nor a title of the many

problems awaiting co-ordination and further research by the physiologist and psychologist. The plethora of osmics is further indicated by the multitude of problems arising from a consideration of the nature of odorous substances (osmyls).

The relations between odour and chemical constitution, emphasised by Haycraft, Cohn, Durrans, and others, by the increasing number of investigations carried out in the industry of perfumery and flavouring materials, has been further extended by recent research on phenomena connected with odorous particles. Tyndall's discovery of the absorption of radiant heat has led to the examination of infra-red absorption by Grijns and the ultra-violet absorption bands by Heyninx, and of correlated phenomena. It is not yet possible to draw satisfactory physiological conclusions from these investigations (the interpretations of which are open to criticism), but it can be stated that potential molecular energy may act on the olfactory cells. Zwaardemaker and Hogewind (1920) have pointed out that in homologous series there is an increase in diamagnetism exactly proportional to the number of atoms in the molecule. However, even Zwaardemaker (1925) is obliged to acknowledge that the precise nature of the olfactory stimulus has not yet been satisfactorily explained, but that "il y a de nombreuses perspectives pleines de promesses, qui pourront être dévoilées en continuant la recherche physique." Even this most cursory and incomplete account of some of the innumerable problems tends to show the need for co-ordination and direction of research, not merely in the interests of pure science, but also on account of the numerous applications in everyday life, in industry, and in medicine. There is ample justification for the organisation of the science of smell as a whole, in order that existing data may be integrated and further research may be organised and directed.

### The Geological Age of the Earth.<sup>1</sup>

IN delivering the twenty-seventh Robert Boyle lecture last year, Prof. J. Joly returned to his attack on the higher estimates of geological time which have been based on the lead-ratios of uranium-bearing minerals. He favours an estimate of 160 to 240 millions of years for the period that has elapsed since the Archaean, and refers to the lead-ratios of certain thorium minerals and to the sodium method of arriving at the age of the oceans as providing confirmatory evidence. It can, I think, be shown that in both cases the data used are misleading, and that the results from both methods can be readily interpreted to support the very estimates to which Prof. Joly considers they are opposed.

On the assumption of uniformitarianism, the salinity of the ocean points to an age of about 80 to 100 million years. The amount of sodium in the oceans has been determined with sufficient accuracy to justify the method, but this cannot be said of the annual increment of sodium brought down to the sea by the rivers. Denudational statistics show that for all the open drainage areas of the world, the total amount of sodium removed in solution is more than 2.1 per cent of the material mechanically and chemically removed from the lands. On the other hand, the rocks actually ex-

posed to denudation contain on an average only 1.3 per cent. of sodium. Thus it appears that the rocks would have to lose more sodium than they had ever contained in order to supply the amounts alleged to have been added annually to the oceans.

Four partial and independent explanations of this remarkable discrepancy can be suggested. (a) To a slight extent the discrepancy is mitigated by the fact that part of the material liberated by denudation remains on the lands and is largely left out of account in the above calculations. (b) Many of the analyses of river-waters for sodium have probably been inaccurate; for unless extraordinary precautions had been taken to overcome the difficulties inherent in such analyses the results would usually be too high. (c) It is also probable that part of the sodium carried by the rivers is cyclic, and the invariable presence of chlorine in river-waters supports this contention. The amount of chlorine in igneous and other rocks is hopelessly inadequate to provide the quantities found in rivers. Volcanic and other juvenile sources have doubtless served to supply most of the chlorine now accumulated in the oceans, but analyses of rain-water show that volcanic sources cannot be of appreciable importance at the present day. The high relief of the existing

<sup>1</sup> Oxford University Press, 1926, pp. 18. 15.

lands provides the necessary head for a vigorous circulation of groundwaters. This is an important factor in chemical denudation, and is likely to be responsible for part of the mysterious sodium chloride that finds its way into the rivers. (d) Another geologically unusual source of sodium supply is found in the easily eroded glacial deposits with which wide areas are now covered.

Neither of the factors (c) and (d) can have been operative throughout geological time, and if it be claimed that they suffice to explain away the discrepancy, then it is only at the cost of admitting that present rates of supply are, for the same reasons, abnormally high.

This raises for discussion the fundamental assumption of uniformity of rate. In recent years the assumption has been widely criticised on the following grounds, all converging to show that present rates of denudation are far higher than those that have prevailed during the average conditions of geological time. (a) The continents are now more elevated and the lands more extensive than they have generally been, since we are now near the close, or just emerging from, a period of great mountain building and uplift. (b) In the past denudation must have repeatedly fallen to an almost negligible value during long periods of quiet peneplanation, and underground waters which are now relatively vigorous must then have become sluggish and relatively ineffective. (c) At least since Cambrian times the greater part of the existing lands have, on balance, received sediments rather than supplied them, whereas at present enormous areas are undergoing rapid denudation. (d) The presence of widespread glacial deposits facilitates rapid local denudation. (e) Finally, human activities have increased the rate by the removal of forests; the tilling of soils; excavations for transport and other purposes; and the addition to the atmosphere of unnatural quantities of acid gases.

A number of geologists have suggested that present rates may easily be from five to fifteen times as high as the average rate for geological time. Moreover, since river analyses for sodium are open to grave suspicion, and the geochemistry of chlorine is still far from being understood, the real income of the oceans in sodium may be less than a third of the amount alleged to be income, which amount is probably partly fictitious, partly capital restored to circulation. It is not unreasonable to combine these sources of underlying error, and to conclude that the age of the oceans may well be twenty times the 80 or 100 million years commonly assigned to it. At least it is certain that the sodium method cannot at present be considered as making any serious contribution to the problem. On its merits the method can be interpreted as pointing to too high an age, and this is a distinct advantage, since it becomes possible, in a way not hitherto allowed for, to admit the probability that the oceans were originally salt, and that additional supplies have since been furnished to them at intervals by juvenile or magmatic waters.

Turning next to the vexed question of the accumulation of lead in thorium minerals, there is no difficulty in demonstrating that the lead-ratios of such minerals are far from leading to concordant or trustworthy results. Thorium minerals of the same geological age give lead-ratios that vary widely among themselves, generally in the direction of lower values than those afforded by

uranium minerals. As a type example of this discrepancy, Prof. Joly takes a pitchblende and a thorite from Ceylon. He says, "whereas the uranium-lead ratio indicated 512 millions of years, the thorium-lead ratio gave 130 millions of years." The actual data for these minerals and other analysed thorites from Ceylon are as follows:

Ref. No.	Minerals from Ceylon.	Percentages of			Lead-ratios Pb/(U+0.37 Th.)	Millions of years.
		U.	Th.	Pb.		
1	Pitchblende	71.40	7.86	4.75	0.066	436
2	Thorite	4.57	62.8	1.28	0.046	304
3	Thorite	3.50	59.2	0.78	0.030	198
4	Thorite	1.62	54.4	0.36	0.017	112
5	Thorite	1.88	65.4	1.71	0.065	429

1. Colonial Reports, Misc. No. 37, Ceylon Cd. 3190, 1906.

2 and 3. Colonial Reports, Misc. No. 87, Ceylon Cd. 7175, 1914.

4. Soddy and Hyman: *Trans. Chem. Soc.*, vol. 105, p. 1404, 1914.

5. Colonial Reports, Misc. No. 74, Ceylon Cd. 5390, 1910.

The ages calculated from Nos. 1 and 4 are lower than those obtained by Prof. Joly because of the adoption of more recent values for the half-periods of uranium and thorium. There is clearly no reason whatsoever for picking out the minimum result given by No. 4 as being in any way more correct than that of the still richer thorium mineral No. 5. The latter gives a ratio practically identical with that of the pitchblende; and when the analyses of the associated thorianites are examined they are found to give ratios varying from 0.048 to 0.075, the average of fourteen ratios being 0.063. The conclusion drawn by Prof. Joly from his comparison of the pitchblende and the thorite No. 4 is based on very limited evidence and is seen to be quite unjustified in the light of the remaining evidence.

The variability of the lead-ratios of thorium minerals suggests that the latter tend to lose lead by the solvent action of percolating waters; and further, that thorium-lead is extracted in preference to uranium-lead. If the lead generated within a uranium mineral forms a highly insoluble uranate, then it is not likely to be easily removed. The lead generated from thorium, however, cannot form a thorate, and within a mineral it is probably present as a comparatively soluble oxide or silicate. Thus there are chemical reasons why one isotope of lead should generally be left while the other is liable to be taken. Atomic weight evidence adds consistent support to this new hypothesis, and for the first time a workable explanation of the long-puzzling discrepancies between uranium and thorium minerals is provided.

If this hypothesis be correct, then the higher lead-ratios of thorium minerals are, like the higher helium-ratios, most likely to approach the true index to age. Thorite No. 5 from Ceylon is likely to give a much more accurate result than No. 4, and, admitting this, there remains no convincing reason for supposing that uranium may have disintegrated more rapidly in the past than we observe it to do to-day. The evidence from pleochroic haloes cannot be accepted as pointing to a declining rate of activity of uranium through geological time, because the part played by the actinium series of elements has not yet been taken into consideration. Thorium haloes reveal no variation of radius with age, thus proving in the most conclusive way

possible that the rate of disintegration of thorium has not varied appreciably in the past. Since the lead-ratios of some thorium minerals are of the same order as those of uranium minerals of the same geological age, it follows equally that the rate of disintegration of uranium must have remained practically constant. It is quite possible that the ages indicated by the lead-ratios of uranium minerals may be a few per cent. too high, but the evidence is overwhelming against Prof.

Joly's contention that they may be so much as four times too high. In the state of our existing knowledge and using the most probable modern data, we may safely say that the age of an unaltered primary mineral is given to a first approximation in millions of years by the formula  $6600 \text{ Pb}/(\text{U} + 0.37 \text{ Th})$ . With Prof. Joly's conclusion we shall all agree: "Kelvin's well-known limitation '20 to 40 millions of years' is gone for ever."  
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### Fuel Research.<sup>1</sup>

FROM time to time the Fuel Research Board, under the chairmanship of Sir Richard Thelfall, and with Dr. C. H. Lander as director, issues technical reports which have received individual notice in NATURE. It has recently issued a general report on its activities, and this is of great interest, because the whole range of the work engaged upon is traversed, and the progress along the lines laid down at the outset can be gauged therefrom. It is fitting to recall the circumstances of the initiation and development of the Board as recorded in the report.

The decision to establish a Board of Fuel Research was taken on February 6, 1917, presumably because the grave difficulties of that time were found to be accentuated by the inadequacy and want of balance in resources of fuels of different types in Great Britain. It was deemed prudent to embark on an intensified scientific study with the resources of the State so as to diminish, if possible, these difficulties and along two main lines of inquiry. The first was to make a physical and chemical survey of the coal seams of Great Britain and a study of the fundamentals of coal. The second line was to make an effort to meet one of the most clamant needs of the times—a supply of liquid fuel home-produced—and simultaneously to provide a smokeless fuel for domestic and other purposes.

Doubtless with the idea that some result of immediate practical value might thereby be obtained, the second of these lines was given precedence, and for this purpose the Fuel Research Station was erected at Greenwich, where the late Sir George Beilby—the first director, and one might almost say the founder—was able to put to a critical test ideas on smokeless fuel production which he had held for many years. This extensive experimental station, which is elaborately equipped for the handling and treatment of fuels by various processes of industrial importance, is described with plans and illustrations in the report now issued.

The report gives an account of the work done there on carbonisation at low temperatures. It must be confessed that the early hopes placed in coal carbonisation at low temperatures have not yet been realised at Greenwich, but let no one conclude that the effort has been in vain. The difficulties are as much economic as technical. The intensive study of carbonisation at low temperatures, which has been a world movement, has clarified our notions on the carbonisation process in general, and the publication of authentic results has equipped with technical data those attacking the problems to-day immeasurably better than the pioneers

of twenty years ago. At the Research Station high hopes are now placed in the use of a suitable vertical retort of metal which has been in operation for some time, but patience will be necessary before assessing its commercial applicability.

Apart from war-time necessities, the return of peace is only serving to emphasise the importance of coal carbonisation, which is very generally regarded as a possible means of increasing the value of coal by exploiting all its potentialities—both thermal and chemical. In order that no obstacle shall prevent the merits of any low-temperature process wherever discovered from receiving recognition, the Fuel Research Station is now empowered to test and report on processes without fee. This service already rendered in two cases (NATURE, February 14, 1925, p. 246, and November 14, 1925, p. 728) is of great public value, for the lack of such impartial tests has led to the dissemination of exaggerated ideas and hopes.

The other main line of work contemplated at the start of the Fuel Research Board was the chemical and physical survey of the coal resources of Great Britain. Now, although much information is in the possession of some consumers as to the relative properties of coals of different origin, there is still a great need for published data of the right kind and extent. It is significant that the only published systematic tests of British gas-making coals are to be found in German technical literature. The tendency of fuel technology is towards increasing refinement of method, and this implies increasing discrimination in the choice of raw material. This tendency is well exemplified by the selection which has to be made in coals for carbonisation in the continuous vertical gas retort. The methods, such as grinding and blending of coals, which are now under experiment and discussion for the production of smokeless domestic fuel, will certainly involve a closer technical control, and therefore a more precise knowledge of the original coals. Such a control may well extend to the composition and character of the ash, which is not without influence on the processes of carbonisation and gasification, and on the behaviour in the boiler furnace. The task of such a survey is a great and protracted one, and eminently suitable for the broad shoulders of a State department. A useful and necessary preliminary step has been to arrange a convention of analytical procedure so that results shall be comparable wherever obtained, and this is already well in hand through the Sampling and Analysis Committee of the Board, which includes members well qualified to speak on such matters. The survey, to be satisfactory, needs to be made with reference to geological and mining conditions, and hence a considerable

<sup>1</sup> Department of Scientific and Industrial Research. Report of the Fuel Research Board for the period ended 31st December 1924; with Report of the Director of Fuel Research. Pp. vi+78+8 plates. (London: H.M. Stationery Office, 1925.) 1s. 6d. net.