we may perhaps grant the possibility of east-west movement for which there is some geophysical evidence. But the "flight from the poles" is another matter, and in fact, according to Wegener's reconstructions, during a large part of geological time the main mass of land in the northern hemisphere was moving, not *from*, but *towards* the north pole. The evidence for these movements is entirely palæoclimatic, and needs to be very convincing to support such far-reaching deductions. Is it convincing? Leverett's comparative studies of European and North American glacial deposits do not bear out the assumption that the main part of the American glaciation is far older than the European. According to W. H. Dall the Miocene glaciation of Alaska is a myth, the main glaciation of that country having occurred in the Quaternary. The mild polar climates of the Upper Eocene cannot be accounted for by movements of the poles, since Berry has shown that a flora allied to the present temperate flora completely surrounded the north pole in high latitudes, forming a ring out of which it is impossible to bring the pole in any direction. The desert deposits of the Mesozoic are practically limited to the latitudes in which deserts are found at present. Wegener's reconstructions do not account at all for the climatic sequence in the Antarctic, as recently set out by Wright and Priestley.[5] There remains the Upper Carboniferous period.

[5] British (*Terra Nova*) Antarctic Expedition, 1910–1913, "Glaciology," by C. S. Wright and R. E. Priestley. London, 1922.

Most meteorologists would say that the development of extensive ice-sheets reaching sea-level within the tropics is inconceivable, and that for the Upper Carboniferous Wegener's theory offers the only possible solution. The succession of glaciations in different continents following a moving pole is not tenable in the light of recent geological work, which seems to demonstrate the approximate synchronism of the glacial maximum in all countries, but this scarcely affects the main problem. A more serious objection is the Upper Carboniferous glaciation of North America, which Wegener's reconstruction places on the equator. Evidence has been found that in Oklahoma, Arkansas, Massachusetts, Nova Scotia and perhaps in other regions also, powerful glaciers reached the sea, and ice-bergs or heavy shore ice transported large boulders fifty miles or more from their original source. The best development is seen in the Squantum beds near Boston, where, in addition to thick tillites, there are seasonally banded clays which are similar in all respects to the 'varve' clays formed during the retreat of the Quaternary ice-sheets in Sweden, Finland and North America. The glacial nature of these beds appears to be incontrovertible, and the well-marked seasonal banding appears to be incompatible with their formation on the equator. Whether Wegener's theory is adopted or not, the climatological problem presented by ice reaching sea-level within the tropics still remains to be solved.

(*To be continued.*)

On the Rare Earths.

THE group of about sixteen elements the oxides of which are popularly known as 'rare earths' are characterised by an exceedingly close relationship in their chemical and physical properties—a relationship which, in its intimacy, is not paralleled by any other group of elements. In consequence of this fact, the task of isolating the individual members of the group has been one of quite exceptional difficulty. Until recent years, practically every reported discovery of a new element of the group was proved, by later searching investigation, to be not one element, but two or more. In addition to this difficulty has been that of distinguishing an alleged new element from some other previously discovered element, with the result that one and the same element was discovered over and over again, each discoverer giving it a separate name. Hence, the chemistry and the nomenclature of the rare earths were for many years in a state of almost hopeless confusion from which they have emerged only during the present century, and particularly in the last decade.

The history of the discovery of the rare earths goes back to 1794 when Gadolin discovered the yttrium earths, out of which a considerable number of separate elements have since been identified. By the discovery of ytterbium and cassiopeium (or lutecium) by Auer von Welsbach in 1906, it was thought that the whole of the rare earths had been discovered, and it was not until the development of the atomic number rule by Moseley that it was found that a space in the series, corresponding to an element with an atomic number of 61, was vacant. There is now fairly conclusive evidence that, after a great amount of work by various investigators, including an exhaustive and negative examination of rare earth fractions by Prandtl and Grimm extending over a year, this element has been definitely identified by the use of the X-ray spectrum. There is also good reason for supposing that with the discovery of illinium, the name given to the supposed new element, the whole of the rare earth elements have been found and identified.

The term 'rare' as applied to these elements is relevant only in the case of a small minority of them. Cerium, believed to be the most abundant, is considered to be little, if any, scarcer than nickel, and many of the others are far from being scarce, even if concentrations of them are not common. On the other hand, a few of the elements appear to be among the rarest known, and this appears to be particularly true of erbium, and the element 61, which has so long eluded the searchers for it and even yet has not been found in measurable quantity.

The primary occurrences of the rare earth minerals in Nature are confined mainly to pegmatite dykes or pegmatitic rocks, considered to have been formed during the last phases of crystallisation and differentiation of an intrusive magma, that is to say, to the phase following acid rock formation. But rare earth minerals are usually not present in important concentrations in the primary rock formations, and it is only by the denudation of the containing rocks and the natural concentration of the relatively heavy minerals set free that accumulations representing any appreciable quantity of the material are formed.

The main source of the rare earths, so far, has been monazite sands found in considerable accumulations in Travancore in India, Bahia State in Brazil, as well as in Ceylon and a number of other places in the world. The composition of monazite sand is complex, but essentially it consists of the phosphates of cerium and lanthanum. But the economic value of the sands depends on the percentage content of thorium minerals which are now used so extensively in the manufacture of the incandescent gas mantle. The cerium content has some economic value, being also used in small proportion in the incandescent mantle industry, and also for the manufacture of ferro-cerium, well known in the form of the sparking type of lighter.

The following are partial analyses of two samples of monazite sand, one from Travancore and the other from Bahia :

	Travancore. Per cent.	Bahia. Per cent.
Thoria	9·43	6·50
Ceria earths	31·90	61·40
Lanthanum earths	28·00	
Yttria earths	0·46	0·70

The yttrium earths have been used in the manufacture of the incandescent parts of Nernst lamps, but for most of the other rare earths no industrial outlet has been found. In some quarters it has been suggested that certain of them may prove valuable as catalysts.

With reference to the close association of the rare earths in Nature, it is obvious that since the chemist finds so much difficulty in separating these by methods of great refinement, the crude large-scale metallurgical processes of Nature must tend to segregate them in groups rather than separately. The rare earth group is scarcely unique in this respect ; the platinum group of metals is a more or less parallel example where the so-called native platinum may be, and often is, a complex alloy of platinum, iridium, osmium, palladium, ruthenium and other metals. All of these metals possess closely related physical and chemical properties which lead to their segregation in the basic and ultra-basic differentiations of an intrusive magma. The rare earth minerals, however, mainly associate themselves with silicious and aluminous magmas.

The conception of atomic numbers and the history of the discovery that X-ray spectra could be used in the identification of previously unknown elements have formed the subjects of numerous articles and communications in the scientific and philosophical press and need only be briefly mentioned here. The names associated with these discoveries include, among others, those of Laue, W. H. and W. L. Bragg, and Moseley, to all of whom great credit is due for their respective parts. Moseley's work in connexion with the development of the atomic number rule has been especially valuable. In the field of the rare earths, the determination of the atomic numbers has revealed definitely the possible number of distinct chemical elements. Between barium with an atomic number of 56 and tantalum with an atomic number of 73 there is room for sixteen elements. Prior to 1923 it was possible to speak of only fourteen of these elements as definitely known, but with the discovery of hafnium with an atomic number of 72 by Coster and Hevesy by means of the X-ray spectra, and the later discovery by Prof. B. S. Hopkins and his associates of what seems to be element No. 61, the sequence from 56 to 73 is complete and justifies the claim that all the rare earths have been discovered. The X-ray method of investigation also leaves no room for assuming that the list of rare earth elements contains duplicated cases, and that the same element may be regarded as two distinct elements under different names. The indications obtained by that method are open to one interpretation only, and those characteristic of a given element are distinguished without difficulty and beyond reasonable doubt.

From its simplicity, ease and rapidity of the experimental examination, the determination of the X-ray spectrum is becoming of the greatest importance in the investigation of particular elements in a mixture, and in the control of separations ; it will most probably, in a large degree, if not entirely, replace the much more complicated and troublesome examination of the light emission spectrum. Not only are elements identifiable by this method with a rapidity and certainty which far surpass those of other methods, but a comparison of the densities of the lines with that of the lines given by a known quantity of a foreign element will give approximate quantitative results.

The method of using the apparatus presents no difficulty. The apparatus is arranged in much the same way as an ordinary spectrometer ; the incident light is replaced by the beam of X-rays from the material under examination, which forms the anti-cathode, in a vacuum tube. The diffraction grating is replaced by the crystal slice, and the telescope and eyepiece (or photographic plate) by an ionisation chamber by which the intensity of the reflected beam may be measured.

LITERATURE CONSULTED.

Levy, S. I. The Rare Earths. 2nd ed. London, 1924.
Prandtl, W., and Grimm, A. *Zeitschr. für anorg. Chemie*, vol. 136, No. 61, p. 283.
Noddack, W., and Tacke, Ida. *Metall u. Erz*, vol. 16 (5/5/26), pp. 985-6.
Lindgren, W. Mineral Deposits. 2nd ed. New York, 1919.
Rastall, R. H. Geology of the Metalliferous Deposits. Camb., 1923.
Harris, A. J., Yntema, L. F., and Hopkins, B. S. NATURE, June 5.

Television.

THE possibility of 'seeing by telegraph' was fully recognised many years ago. The discovery that the electric resistance of selenium varied with the intensity of the light falling on it suggested to Professors Ayrton and Perry, amongst others, that the method was theoretically feasible. It was soon found out that selenium failed to respond quickly enough to the rapid changes in light intensity necessary for television, and it was not until the photo-electric cell had been perfected that inventors seriously attempted to solve the problem. The analogous problem of sending photographs and pictures by telephone wires or by radio waves, or by both these methods, we can consider as solved. It is now done commercially. Doubtless great improvements in the method will be introduced, and before very long every one will accept it as a commonplace operation and cease to regard it as wonderful.

The problem of television, however, is an immensely more complicated one, and even the most optimistic of scientific men had begun to think that it would be