the method of BIELSCHOWSKY, ganglioncells were scarce, and in fact I often looked in vain for them. It was only in the nerve plexus

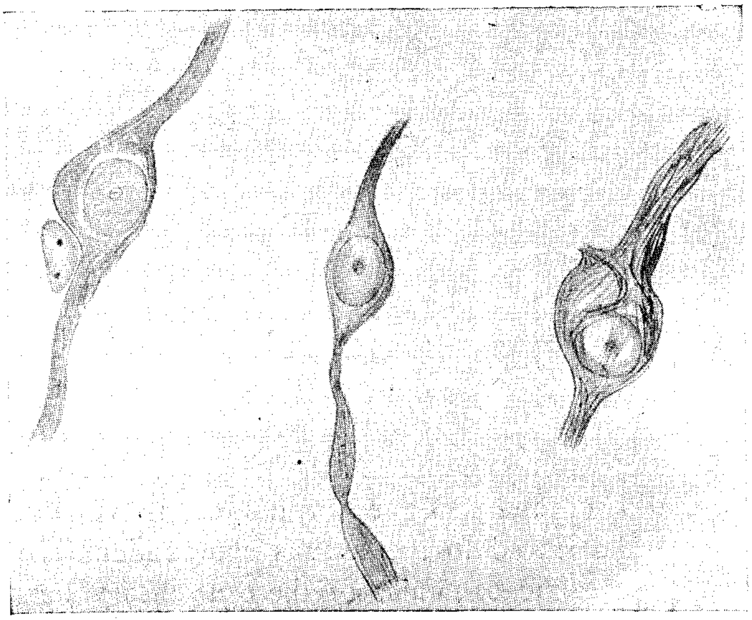

Fig. 11, 12 and 13. Ganglioncells from the plexus ciliaris of the human eye.

of the corpus ciliare that ganglioncells were to be found, of the type figured in fig. 11, 12 and 13. It therefore seems improbable that they should exist in the numbers required for the theory of INGLIS POLLOCK. So from this point of view too renewed research is necessary and especially it will be necessary to verify the interesting results of the last-named author.

Leiden, April 1915.

Geology. — *"How volcanism might be explained."* By Dr. C. G. S. SANDBERG. (Communicated by Prof. Dr. C. E. A. WICHMANN).

(Communicated in the meeting of April 23, 1915).

To explain the phenomenon of volcanic eruptions and the mode of their origin, it has long been considered necessary to assume that large quantities of sea-water were suddenly brought in contact with incandescent and liquid magma, by means of deep-reaching fissures or crevasses in the crust of the earth.

The fact that the gaseous volcanic emanations showed some similarity with the constituent elements of sea water and the proximity of the seat of volcanic activity to marine areas, led to our looking for a causal connection between these phenomena.

The theory built up on it is now acknowledged untenable, both as some volcanic areas proved to be situated at considerable distance from the sea and because it was admitted impossible for sea water to penetrate to the magma along a fissure, only to be violently expelled again along another, a more difficult passage.

A. DAUBRÉE (1) experimentally tried to establish the possibility of the necessary explosive energy, being furnished by the contact of water, reaching magma by capillary attraction, through the sedimentary strata; this assumption equally proved untenable however.

In short we may say that since, the solution of the problem has been sought in connection with the action of radioactive elements of the interior of the earth, with cosmic influences (solar and lunar attraction, maxima and minima of sun spots, etc.) or else in connection with mountainfolding. At the same time it was considered admissable to accept that both, the eruptive power and the presence of vapours and gases, are primordial elements of the magma (2).

Lately A. BRUN (3) denied the existence of water-vapour in large quantities in volcanic emanations, an assertion which has been refuted by the results of L. DAY and E. S. SHEPHERD's researches (4).

When now we examine the way in which volcanic regions are distributed over the earth, we notice that their situation coincides in general with the steep flanks of the G. A. [1]) which are, according to the doctrine of isostatic movements of the earth's crust, *the faulted and fissured regions of our globe.*

In the author's opinion it would not seem improbable, that a causal connection exists between the faulted condition of these regions and the occurrence of volcanism at those very places.

The products of erosion of the G. A. transported to the G. S. are deposited in *sea-water.*

Those sediments consequently consist of solid elements mixed with sea-water.

In the G.S. the liquid constituents of the upper layers surpass the solid material (Deep-sea ooze).

As sedimentation progresses, the proportion of solid material in the mixture increases, through entassement.

Ultimately the water contents of the sedimentary deposit will not exceed the capacity of the total of capillary- (pore-)spaces, left between the adjacent particles of solid material, of which the sediment is built up. [2])

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[1]) In what follows the initials G. A. and G. S. will be used respectively for the words Geo-anticlinal and Geo-synclinal.

[2]) The question whether larger cavities must be considered existable at very

To arrive at an appreciation of the quantity of sea water, which thus could possibly be contained in sedimentary strata, we have first to examine what the pore space in sedimentary strata can amount to.

If the constituting elements were perfectly spherical, the amount of pore space would depend only on the way of their being piled up, and would vary between the values of 25,95 to 47,64 volume percentage (5) (6) (7).

As the constituting elements are not perfectly spherical however, the pore space of sediments has to be determined empirically; it was found to vary between the values of 16 to 70 volume percentages [1]). And it is a remarkable fact that pore space-capacity of sedimentary strata increases with the diminution of their constituting elements.

The above holds for deposits situated relatively near to the surface; the question is now whether we may accept a similar conclusion for deposits situated at very great depths beneath the surface?

The overwhelming amounts of oil, water and gas met with in sedimentary strata at depths of 1000 meters and more, already seem to point towards such conclusion not being unlikely.

But we have more direct indications to go by in the ascertained pore space of Dakota sandstone (Cenomanian) and the Potsdam sandstone (Paleozoic).

The researches of F. H. King showed that, under their hydrostatic levels, the Dakota sandstone 15 to 38 and the considerably older Potsdam-sandstone contains 10 to 38 volume percentages of water [2]) (5).

The first mentioned deposit extends over an area of over 900,000 km^2., the latter over an area of more than 350,000 km^2., both with an average thickness of about 300 meters.

The former is covered in the Denver District by more recent deposits having a total thickness of 2000 m., the latter by a series

great depths, is left undiscussed here; should we accept the possibility of it, the proportion of occluded water might be greater still.

[1]) loc. cit. (7) p 127 and (5).

[2]) It is true that Newell found that a marble only contained 0,62% of water. But as a marble is not a sedimentary deposit but a modification of it, this percentage (as little as that of eruptive rocks) may not be taken as a basis for an appreciation of the amount of water which can be stored up in the pore-space of sedimentary strata, laid down in the G.S. The only conclusion we might perhaps be allowed to draw from it is, that as the percentage is yet considerable relatively, in spite of the intense metamorphism the deposit underwent since its deposition the original contents must have been much greater.

of more recent deposits, the total thickness of which amounts, for the paleozoic only, to over 12.000 m. in the Apallachian.

Here then we have an instance of well developed, similarly constituted sediments, deposited over vast areas, differing considerably in age and covered under layers of sediments, whose thickness amounts to 2000 m. and 12.000 m. and more.

Yet their pore-space was and is, very nearly identic, *and moreover coincides with that of similar sediments which both are recent and situated close to the surface.* (5).

On the ground of these facts, the conclusion does not seem unwarranted, that the pore space now proved to exist in these sandstones, was also present in them when they were still lying in the G.S. covered up by a powerful mass of more than 2000 m. and 12000 m. thickness.

It would not be difficult to increase the instances given above.

If it seems legitimate, on the ground of the above detailed facts to conclude that pore space in sedimentary rocks is existable at depths of more than 12.000 m., the recently published results of F. D. ADAMS's researches and L. F. KING's calculations proved that we may yet expect them to exist at far greater depths, *even when those pore spaces were not filled up by some liquid or gas imprisoned in them.*

Were these pore spaces filled with a liquid or gas, we might expect them to be still extant at depths where the temperature is so high, that under its influence the sediments would liquefy.

The question is now whether we may take it as probable, that the water originally occluded in these sedimentary deposits, will not have been expelled from there (by the tension of the vapour-converted water of underlying strata), long before those sediments could have reached the zone of liquefaction.

For should the water (vapour) still fill the pore-spaces, a sufficiently sound basis for explaining the origin and mechanism of volcanism were to be found, in the quantity of occluded water (vapour) and the high tensions acquired by it, under the influence of excessive high temperatures reigning in the magmatic zone.

The sedimentary rock would gradually pass into a plastic and liquid condition, during its downward course in the G. S.

And as the steep flank of the G. A. adjacent to the G. S. constitute a faulted and fissured region, the possibility might not be considered excluded that part of those vapour-tensions will discharge themselves into those fissures, thus creating the volcanic phenomenon at the surface of the earth.

Another possibility which we might conceive, would be that under the influence of these tensions the covering sedimentary masses in the G. S. were upheaved.

That might ultimately lead to the formation of overthrust planes (nappes de charriages), through a lateral bulging out of the raised up masses.

At last a local rupture through the enveloping strata might give birth to volcanic eruptions, which then might be sub-marine.

We might conceive the mechanism of volcanism in this way.

When by the action due to isostatic influences, a fissure or fault be engendered in the region of the steep flank of the G. A., or when in the raised up part of the G. S. a rupture should result from the high tensions prevailing there, the vapour tensions existing in the vicinity of such faults or fissures would discharge themselves entirely or partly in such fissure or fault.

Part of the plastic (or liquid) rock would be carried along, as water overcharged with carbon-dioxide is carried along by sudden and sufficient relief of pressure.

The subsidence of sedimentary deposits ever continuing, through accumulation of the products of erosion in the G. S., water (vapour-) charged sediments would ever and anon be conducted into the regions of excessive high temperatures; this might account for the periodicity of volcanism [1]).

Thus the appearance of volcanism might be expected in those regions of the earth, situated outside the G.S., which by some cause or other, are moving in centripetal direction or have lately done so.

Should on this basis a solution be offered for a certain amount of questions regarding the mechanism and origin of volcanism, the question still remains whether it may be. considered plausible that the sea water imprisoned in the pore spaces of sedimentary strata, may be there still when these sediments have reached depths where liquefying temperatures are reigning.

The vapour tensions, it might be argued, there prevailing, must have expelled all the water once occluded in the pore space of these sediments, long before such deposits could have reached the vicinity of the regions of those high temperatures.

It is known however that the frictional resistance of liquids in capillary channels is considerable, being for a given flow, per unit

1) I might be allowed to draw the attention to the fact that the absence of water in liquid state on the moon, and the absence of erosion, sedimentation and isostatic movements as a consequence of it, may perhaps stand in causal relation to the absence of periodicity of lunar volcanism, in contrast with terrestrial volcanism.

of time, in direct ratio to the length and in inverse ratio to the fourth power of the radius of the channel.

How considerable this resistance is in relatively porous rock, as e.g. the grès bigarré, is shown by A. DAUBRÉE, in a note on his experiments about capillary attraction.

DAUBRÉE draws attention to the fact that a thin disc of sandstone 2cm. thick, which completely shuts off a basin partly filled with water, is able to prevent water-vapour to escape (through the body of the rock) *even when the vapour has acquired a tension of several atmospheres.*

When now we take into consideration that the ratio of the diameters of capillary channels in sands and those in clays may be as from 1000 to 1, we shall be able to form an idea of the excessive resistances prevailling in finegrained sediments. (In inverse ratio to the fourth power of the radius).

Where moreover, the researches in folded areas have shown that the magnitudes of such fine-grained sedimentary (argiliceous-, impermeable-) strata may amount to hundreds and even thousands of meters in thickness, covering the total extent of the G.S., it does not seem unwarranted to pose the possibility of such impermeable strata preventing the water (vapour) occupying the capillary channels of the sedimentary deposits, from being expelled therefrom by the influence of the high temperatures and tensions engendered in those strata, on their way down to the zone of liquefaction.

This contribution purposes to point out a direction in which it might be considered possible to look for a satisfactory solution of the problem of the origin and the mechanism of volcanism.

(In the paper now in course of preparation, in collaboration with others, and which we hope to be able to publish in the Journal of Geology (Chicago, U.S.A.) before long, we intend to calculate the values of vapour-tensions at temperatures of 1000°—1200° C. in connection with the quantity of water supposed to be occluded in the sedimentary strata and their respective volumes; further to approximate the frictional resistance in sedimentary strata built up from clay and (or) sand, in order to approximate how thick a body of clay or sand should be, so that the frictional resistance (in its capillary channels) be sufficient to prevent the water occluded in the underlying sedimentary masses, to be expelled therefrom).

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Astronomy. — "*Observation of the moon during the Eclipse of the sun on Aug.* 21 1914 *and of the Transit of Mercury on Nov.* 7 1914, *made in the Leiden Observatory.* By J. Woltjer Jr. (Communicated by Prof. E. F. van de Sande Bakhuyzen).

(Communicated in the meeting of April 23, 1915).

I. Solar-eclipse of August 21, 1914.

During the eclipse of Aug. 21 1914, sun and moon passed over the meridian. At the suggestion of Professor E. F. van de Sande Bakhuyzen I have observed the declination of the south-limb of the moon with the transit-circle. The results of this observation including details concerning the method of reduction will be given here.

In order to obtain as large a number of pointings as possible Professor Bakhuyzen kindly undertook the reading of the microscopes (including those for the observation of the nadir).

The observed declination depends on the observation of the nadir. As two of the pointings had naturally to be made far outside the meridian, it was necessary to give special attention to the inclination and curvature of the horizontal wires. In 1911 an investigation on these points had been made; for this purpose a collimator provided with a level had been mounted on the south-pier; by means of one of the foot-screws the middle of the two horizontal wires of the collimator was pointed on various points of the horizontal wires of the meridian-telescope; by reading the level each time the inclination of the optical axis of the collimator becomes known and thus that of the line from the middle of the objective to the special point of the horizontal wire on which has been pointed.

The pointings were made on five different points of each wire,