contains no bentonite. On the other hand, it contains at least one bed of fairly fresh crystal tuff whose composition is approximately that of the igneous rock andesite. It is altogether likely that careful tracing of these tuffs and zeolite beds will demonstrate that they have an enormous lateral extent, comparable perhaps to bentonite beds. If so they would be of considerable value as precise correlative units.

As these zeolites must have formed at a temperature approximating the mean annual temperature at the earth's surface their occurrence suggests the possibility that the zeolite gels of soils may, under favorable conditions, crystallize into definite minerals. Indeed there appears to be a significant analogy between the occurrence of a natural sodium aluminum silicate gel recently described by Burgess and McGeorge[2] from the alkali soils of Arizona and this occurrence of analcite, a crystalline form of sodium aluminum silicate, in the beds of an ancient alkaline lake. Hence it seems within reason to expect that certain fossil or perhaps even recent alkali soils might contain definitely crystallized zeolites.

A more complete account of these zeolite beds together with the data which led the writer to the conclusions expressed here will be presented later in a report by the U. S. Geological Survey treating the mineralogy of the Green River formation.

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THE ADHESION OF MERCURY TO GLASS

The adhesion of *small* drops of mercury to the clean sides of glass vessels is a matter of common laboratory observation. It is seen in partly filled bottles of mercury that have been recently shaken, and it is often noticed in the glass chambers of mercury pumps. Yet larger drops break away leaving the glass "dry."

Observations on the "wetting" of clean surfaces of glasses of special constitution, as evidenced by the *rise* of the mercury meniscus against such surfaces when vertical, have been reported by Schumacher.[1] The observations reported here are of a totally different sort. The glass is that of ordinary laboratory lenses—probably crown glass as the index of refraction in each case was between 1.53 and 1.56. These were cleaned by rubbing the surfaces with a piece of absorbent cotton wet with absolute alcohol. The mercury was singly distilled, and to lessen contamination was transferred from vessel to vessel through a glass siphon that was started by a current of dry air. Before each set of observations the mercury was passed through a paper and cottonwool filter to free it from dust caught on its surface. The observations were made in the open air of the laboratory, so it will be evident that no claim for extreme cleanness of surfaces can be made.

If the surface of a glass lens, cleaned as described above, be brought into contact with a pool of mercury so that the lowest point (the apex) of the glass is say 0.2 mm. below the level of the mercury surface, the air adherent to the glass depresses the mercury in contact with it and holds it out of contact with the glass. After an interval, which may vary from a fraction of a second to several minutes, the fluid pressure seems to drive the air away from the apex of the lens and then, in a flash, a bright mirror spreads over the glass. This may be interrupted by a few small bubbles of imprisoned air. The edge of the mirror surface, or the "circle of extreme contact" of mercury and glass, is well above the general level of the mercury pool—a meniscus being formed at the edge of which the mercury is lifted a millimeter or more. As no reference to this phenomenon could be found in the literature available it was thought worth while to make some quantitative observations on it.

The disposition of apparatus is shown diagrammatically in fig. 1. *A* is the pool of mercury—about 18 cm

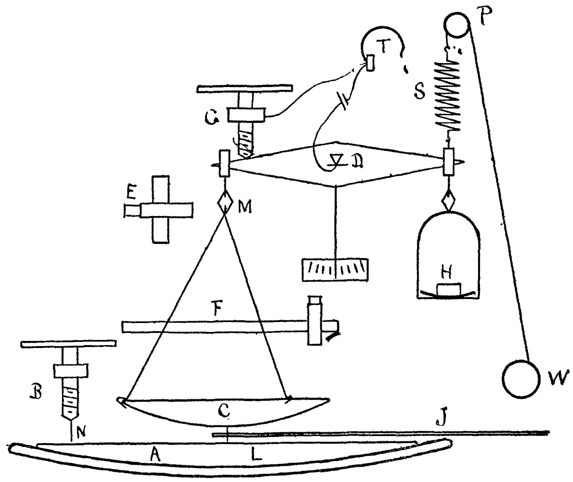

Fig. 1

across—in its shallow glass basin, *B* is a micrometer screw on a fixed stand by which the needle point *N* may be adjusted to contact with the surface of the mercury pool, and by means of which changes in the level of *A* may be followed. *C* is the lens of measured curvature, the lower surface of which is under observation. The lens is held in a frame of steel wires

[2] Burgess, P. S., and McGeorge, W. T., Zeolite formation in soils. Science, new ser., vol. 64, pp. 652–653, 1926.

[1] *Jour. Amer. Chem. Soc.* Vol. 45, No. 10.

that hangs from one hook of the balance arm *D*. Changes in the level of the lens surface may be measured by observing the displacement of the needle point *M* (rigidly attached to the steel frame) through the reading microscope *E* (scale vertical). The vertical motion of *C* is controlled by the micrometer screw *G* which acts directly on the balance arm *D*. *H* is a counterweight in the second pan of the balance to maintain contact between the balance arm and the point of the screw *G*. *J* is a strip of thin ebonite that carries at its end a "distance piece" *L* formed of 2 mm of the point of a needle. The top of *L* is held against the apex of the lens by the small stiffness of the ebonite strip *J* and the lens is then lowered until the point of *L* comes into contact with the surface of the mercury pool *A*. The reading of the level of the needle point *M* in this position together with the length of the distance piece gives a datum level from which the relative levels of the apex of the lens and the surface of the pool of mercury can be determined, account being taken of changes in the level of the pool itself as revealed by the reading of the screw head at *B*. The level of the pool is of course altered either by the immersion of part of the lens itself or by the drawing up of mercury into the meniscus. Fig. 2

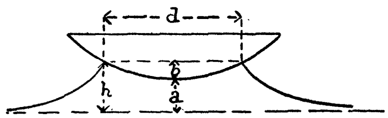

FIG. 2

shows the lens and the mercury meniscus. The diameter of the circle of contact (*d*) is observed *through* the lens by the reading microscope shown with scale horizontal at *F* (fig. 1). From this measurement and the known curvature of the lens the distance *b* (fig. 2) follows from geometry, and this with the distance (*a*) of the apex above the level of the pool gives the maximum lift (*h*) of the mercury in the meniscus.

With plano-convex lenses no correction for refraction in the observed value of the diameter of the circle of contact was necessary. For other lenses the value of *d* is obtained from the observed magnitude by the use of a curve in which the known distances of the points of a pair of micrometer calipers are plotted against their distances as observed through the lens by the microscope *F*, the points being held against the lower surface of the glass.

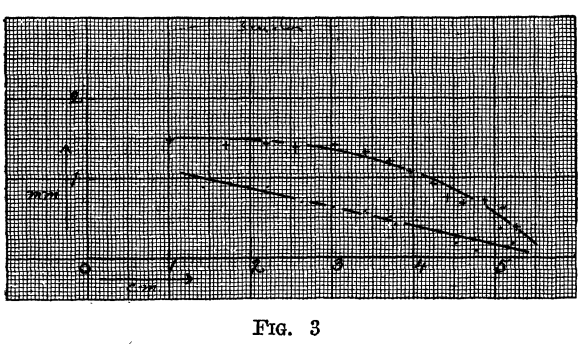
FIG. 3

In all cases within the range available the mercury rose above the level of the pool although the rise was less for circles of contact of larger radius. The rise on gradually lowering the lens into the mercury was always less than the rise found for the same circle of contact on lifting the lens out of the fluid. Fig. 3 shows the values obtained from a plano-convex lantern condenser of radius of curvature 10.41 cm[2]. The abscissae are radii of the circles of contact and the ordinates are the heights of the edge of the mercury meniscus above the general level of the pool. The values plotted in dots were found as the lens was slowly lowered into the mercury, the fluid rising over the clean glass. Those shown in crosses were from measurements made as the lens was gradually lifted, the fluid slipping back over surfaces that had been previously covered with mercury. The curve seems to indicate a vanishing value for *h* just beyond the limit of observation, at a circle of contact of radius 5.75 cm which would lead to an angle of contact for the mercury and lens used of nearly 147°. No test seemed feasible for the electrification of the freshly exposed surfaces, but usually *dry* glass plunged into mercury is strongly electrified on withdrawal. Whether the moisture of the summer air kept the surface sufficiently conducting to discharge it is not known, but the electrical grounding of the mercury pool produced no apparent difference in the results. All the curves obtained are of the same general nature with the one shown in the figure. With all of the lenses, independently of their particular curvature, the lift of the mercury at the edge of the meniscus was about 0.16 cm though with a sample of freshly distilled mercury a lift of 0.200 cm. was once obtained.

A noteworthy feature of the phenomenon was the way the mercury gradually passed from the circle of contact that had just been rendered unstable, by the lifting of the lens, to a new stable circle. Usually it would move fairly quickly and come to rest again within a minute or two; but when the mercury cov-

[2] The radius of curvature was found by rolling calibrated "bicycle balls" of different sizes into contact

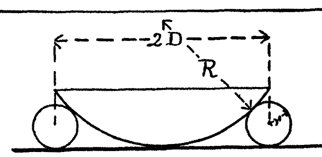

FIG. 4

with the lens as it rested on a flat surface and then measuring the distance from ball to ball with a reading microscope. In Fig. 4 $R = \frac{D^2}{4r}$.

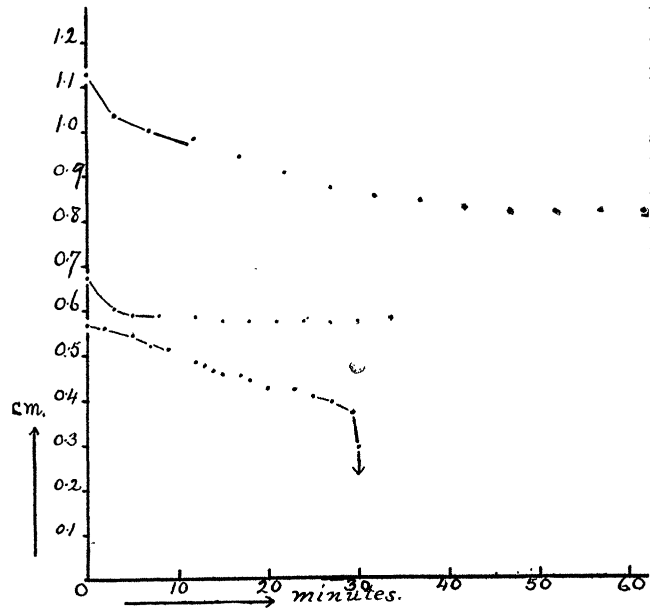

Fig. 5

ered only a small area near the apex of the lens it might be a half an hour or more before the new position was finally reached. Figure 5 shows some typical cases. The ordinates are radii of the circle of contact in cm and the abscissae are times in *minutes* from the first reading of the circle of contact after the lifting of the lens, the level of the lens being unchanged during the series of readings shown in the plot. Those plotted in the upper curve took over an hour to become stable. For the first of the series h was 0.161 cm and for the last 0.155 cm. In the final position the mercury seemed to be in a state of abnormal adhesion to the glass ("stuck") for a careful lifting of the lens through 0.003 cm did not alter the radius of the circle of adhesion, and this seemed *quite stable* at the increased height above the mercury pool. Another lift of 0.005 cm, however, started a rapid shrinking of the radius that led to the breaking of the meniscus in a few seconds. The middle curve is a record of the attaining of stability from a circle of radius smaller than that of the upper curve. The lowest line of dots shows a case where the contraction of the circle reached the point where it rapidly became more and more unstable, leading to the breaking of the meniscus just after the last observation plotted. One would naturally try to account for these peculiarities by invoking tremors in the building, but the apparatus was on a firm table on the cement floor of the laboratory, and the readings were made at night when the observer was alone in the building. Usually, as noted in connection with the upper curve of figure 5, after the circle had attained a stable position the lens might be lifted from 0.001 to 0.002 cm before the edge would be "pulled away from its moorings" to recommence its slipping over the glass to a new position of rest.

To measure the force exerted by the mercury on the glass the following additions were made to the apparatus. A light spiral spring S—from a Jolly balance —was attached to the second balance hook of the arm D (Fig. 1) and from its upper end a string ran over the pulley P to the small winch W. By means of this it was possible to exert small but definite forces upwards on the pan H until the contact between the screw point of G and the balance arm just broke, the break being indicated by the telephone circuit T.

The meniscus being formed, the winch was slowly turned until the contact at the point of G was just broken. The balance arm was then in equilibrium between the forces exerted by the mercury and those exerted by the masses suspended from the hooks and the force set up by the spring S. The screw G was then raised out of the way, the position of the pointer of the balance was noted, the levels and diameter of the circle of contact read, then the meniscus was broken and the change in the masses on the pan of the balance to restore equilibrium at the same pointer reading gave a measure of the force exerted by the mercury on the glass. The vertical force on the lens from the mercury came from two sources. First, that due to the difference between the atmospheric pressure over the circle of contact and that due to the smaller pressure of the mercury in contact with the glass. Second, there was the vertical part of the force due to the surface tension of the mercury around the circumference of the circle of contact. A series of measurements was made for different circles of contact and for different lenses, all of which led to the magnitudes to be expected from the known constants of mercury. These observations were of no use as determinations of the surface tension of mercury for the following reasons: (1) The value for the surface tension comes from the difference between the observed equilibriating force and the force due to the difference of pressures as noted above, and, except for the smallest circles of contact, these are too nearly of the same magnitude to give their difference much value. (2) Owing to the great density of mercury errors in the diameter of the circle of contact, the variation of the curve of contact from a true circle and small errors in the determination of the levels combined to prevent the required degree of exactness. Then, too, there was the further uncertainty due to the phenomenon of sticking as the lens was lowered enough to break contact with the control screw before the observation was made.

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