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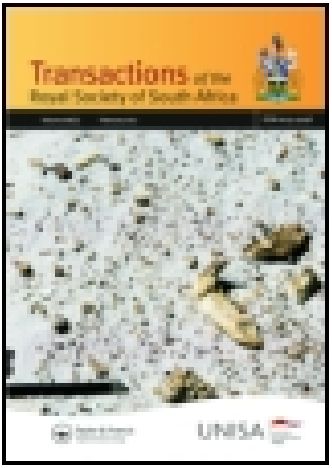

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ON THE VARIATIONS OF LEVEL OF THE CAPE TRANSIT-CIRCLE

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pose the rock, passing through concentric coatings quite unaltered, and forming miniature black ridges through them.

The hornblendic portion of the dyke passes gradually into a very compact and highly crystalline basalt. The basalt passes into orthoclase, which in its turn merges into a mass mainly composed of augite in coarse crystals. And these variations continue till the dyke terminates on the west side in a vertical wall of highly crystalline basalt, the beds of the adjoining stratified rocks being undisturbed, though the effects of heat are visible on east and west sides for a considerable distance Now, though there is a great probability that the hornblendic rock referred to above is a later injection into the main dyke, the conditions under which it was formed must have been peculiar, as the gradations from trachyte on the one side and basalt on the other are perfect. The same inference cannot be made with regard to the other variations in the dyke, which in many places show a tendency for the particles of a single mineral to aggregate themselves together over considerable areas, and thus increasing the difficulty of finding any name sufficiently comprehensive and yet distinctive for a dyke of this magnitude and condition.

A few broad terms in connection with erupted rocks fit for a geologist to handle in the field is a great want. Mineralogy gives no assistance; it, of all the sciences that cluster round the broad term geology is the oldest, the most pretentious, and least satisfactory.

ON THE VARIATIONS OF LEVEL OF THE CAPE TRANSIT-CIRCLE.—By W. H. FINLAY, B.A.

[Read 1884, Sept. 3.]

The Cape transit-circle was erected in 1855 and brought into regular use in 1856. From that time to the present date a continuous series of observations has been maintained for determining the instrumental adjustments.

The instrument is one of the largest of its class and is exactly similar to the Greenwich one. The piers consist of a few large blocks of very hard sandstone from a quarry near Tiger Berg, and rest on the rock; every care was taken to cement them into two solid masses. It was expected with such a strong and massive instrument that the changes in the adjustments would be very slight indeed, but this expectation was not fulfilled.

For the first three or four years the instrument was fairly steady, but from about 1860 up to the present time there have always been large and well-marked changes of position in the course of the year.

This is more especially the case with the level error, and a constant and continuous watch has consequently been kept on it.

The telescope cannot be reversed on its bearings and is not adapted for the application of an ordinary spirit level; but the level error and zero of the vertical circle (or Nadir-point reading) are determined by observing the images of the wires reflected from a trough of mercury, an observation admitting of extreme nicety and accuracy; the error of azimuth is determined by observations of polar stars.

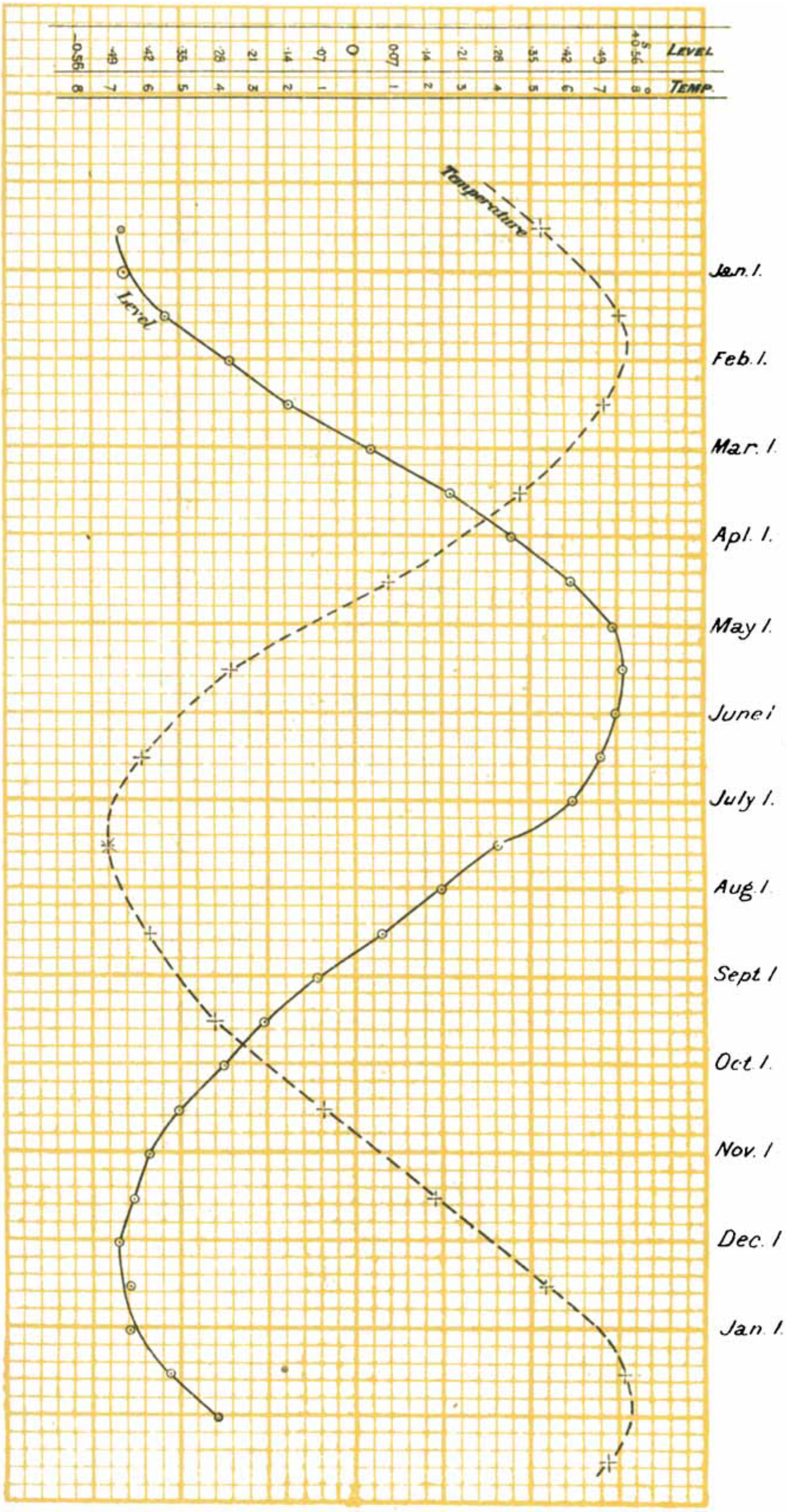
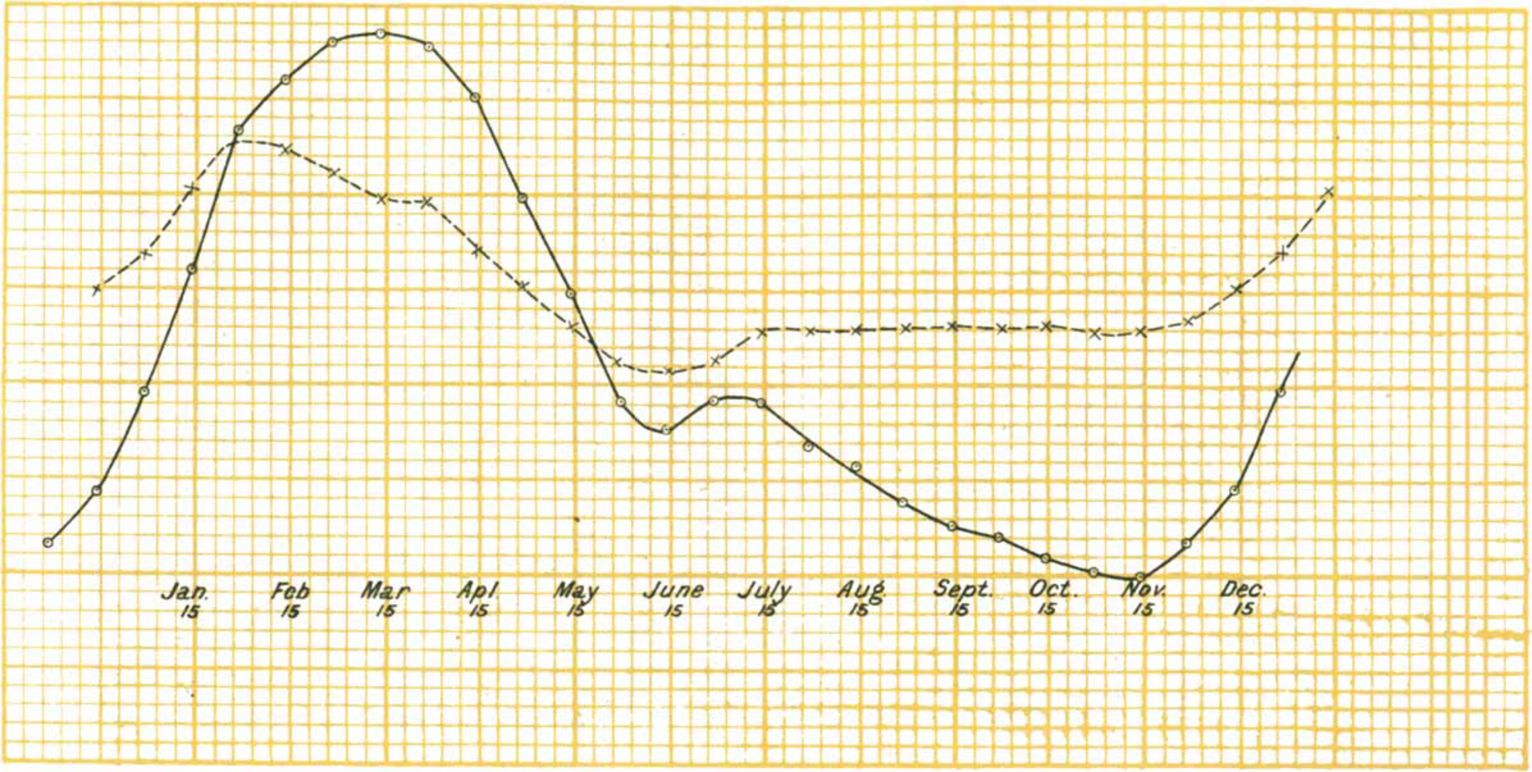

LEVEL
TEMP.
+0·56
·49
·42
·35
·28
·21
·14
0·07
O
·07
·14
·21
·28
·35
·42
·49
−0·56
8°
7
6
5
4
3
2
1
1
2
3
4
5
6
7
8
Temperature
Level
Jan. 1.
Feb. 1.
Mar. 1.
Apl. 1.
May 1.
June 1
July 1.
Aug. 1.
Sept. 1
Oct. 1.
Nov. 1
Dec. 1
Jan. 1.

FIG. I.

FIG. 2.


Jan. 15
Feb 15
Mar 15
Apl. 15
May 15
June 15
July 15
Aug. 15
Sept. 15
Oct. 15
Nov. 15
Dec. 15

These adjustments are very constant from day to day and throughout the day; no appreciable change has been detected in them depending on the time of day, though the range of temperature from noon to midnight is often very large.

The observatory is situated on the northern end of a small hill, and is only 37 feet above sea-level. The Liesbeek on the west and the Black river on the east, which carry off a great part of the rain falling on the Flats and the East side of Table Mountain, overflow their banks in the winter, and a large sheet of water stands for a considerable time to the north and north-east of the hill. It has generally been supposed hitherto that the rains or pressure in some way from this standing water were the chief agents in producing the changes of adjustment in the Transit-circle, and it was to test the truth of this supposition that I undertook the present investigation.

Tables of the values of the errors were formed for every half-month from 1856 to 1882 by taking the mean of three or four determinations about the first of the month as the error on the first, and similarly for the 15th. The means of these semi-monthly values, though not strictly the mean of the year, will not differ much from the true mean. On three occasions, in 1856, 1860, and 1872, the amount of the level error was reduced by the insertion of tinfoil under the bearing plate of the western pivot; but as the level error was taken before and after these changes I have been able easily to allow for these changes and tabulate the errors in one uniform system. The following are the means of the 27 semi-monthly results for the level error, to which I propose chiefly to confine myself to-night :—

	s.		s.		s.		s.
Jan. 1 ..	—0·58	Apr. 1 ..	—1·35	July 1 ..	—1·47	Oct. 1 ..	—0·77
,, 15 ..	—0·66	,, 15 ..	—1·47	,, 15 ..	—1·32	,, 15 ..	—0·68
Feb. 1 ..	—0·79	May 1 ..	—1·55	Aug. 1 ..	—1·21	Nov. 1 ..	—0·62
,, 15 ..	—0·91	,, 15 ..	—1·57	,, 15 ..	—1·09	,, 15 ..	—0·59
Mar. 1 ..	—1·07	June 1 ..	—1·56	Sept. 1 ..	—0·96	Dec. 1 ..	—0·56
,, 15 ..	—1·23	,, 15 ..	—1·53	,, 15 ..	—0·85	,, 15 ..	—0·58

A minus sign denotes that the western pier is lower than the eastern, and an error of — 1·0s. corresponds to a relative depression of ·0048 of an inch. Thus the western pier is about $\frac{5}{1000}$ths of an inch lower in May and June than in December. If the differences of these values from the mean of all be laid down to scale and a curve swept through them, we have the continuous black curve in fig. 1, shewing the relative motion of the east pier. To find a formula which will represent these changes I assume—

$$L = c + a \sin (\oplus + A) + b \sin (\oplus + B.)$$

Where L = the level error at any time

$$\oplus = 0^\circ \text{ for Jan. 1, } 15^\circ \text{ for Jan. 15, \&c., \&c.}$$

and c, a, b, A and B are constants to be determined.

Each of the semi-monthly values above gives an equation of this form, and solving the 24 equations by the method of least squares I find—

$$L = \overset{\text{s.}}{-1{\cdot}035} \; \overset{\text{s.}}{-0{\cdot}519} \sin (\oplus - 55^\circ\ 3') \; \overset{\text{s.}}{-0{\cdot}044} \sin (2\oplus + 203^\circ.2'.)$$

If with this formula we compute the valeus of L for each half month, we get the following differences between the computed values and the observed values of the table above:—

	s.		s.		s.		s.
Jan. 1 ..	+0·01	Apr. 1 ..	0·00	July 1 ..	—0·03	Oct. 1 ..	—0.01
,, 15 ..	+0·01	,, 15 ..	0·00	,, 15 ..	+0·01	,, 15 ..	—0·01
Feb. 1 ..	—0·02	May 1 ..	0·00	Aug. 1 ..	0·00	Nov. 1 ..	—0·01
,, 15 ..	—0·01	,, 15 ..	+0·02	,, 15 ..	0·00	,, 15 ..	—0·02
Mar. 1 ..	—0·01	June 1 ..	+0·02	Sept. 1 ..	+0·01	Dec. 1 ..	—0·01
,, 15 ..	—0·02	,, 15 ..	0·00	,, 15 ..	0.00	,, 15 ..	—0·02

These residuals are so small that we may say the formula represents the observed values perfectly.

The question now comes "To what cause are these changes due? Will rainfall or temperature account for them?" The following table gives the mean monthly amount of rainfall and the mean monthly temperature of the air for the same years:—

TABLE II.

Rainfall.		Temp.	Rainfall.		Temp.
	in.	°		in.	°
January	0·55	68·86	July	3·79	54·24
February	0·61	68·46	August	3·40	55·36
March	1·03	66·03	September	2·00	57·24
April	1·84	62·20	October	1·78	60·33
May	4·13	57·78	November	1·13	63·52
June	4·53	55·17	December	0·95	66·67

Mean monthly rainfall = 2·14 in., mean temperature = 61·32°.

The temperatures are taken from the readings of Dollond's thermometer in the window-crib close to the transit-circle, and though not representing perfectly the shade temperature, on account of the position of the crib, yet they have the advantage of being a continuous series by the same thermometer in the same position.

In considering the rainfall I am at a loss how to represent its accumulated effect, whether simply according to the amount of rain or according to some more complex law. The sudden increase of rain in May and June agrees well with the fall of the level curve towards the end of June, but while the rainfall has reached its average amount in September, the level curve still continues to fall till the end of November. This, however, may be due to accumulation of rain. Again, the level curve mounts steadily through March and April, although the rainfall in April is three times as much as in January or February. On the whole, I do not think the rainfall is a perfectly satisfactory determining cause.

The dotted curve in fig. 1 represents the variation of the monthly temperatures from the mean of the year laid down to scale so that the amplitudes of the temperature curve and the level curve shall be nearly the same. The perfect similarity of the two curves is striking, and it is impossible to withstand the conclusion that the two curves are intimately connected, and that the changes of level are in some way due to the changes of temperature throughout the year. But now a curious point arises—the times of maxima and minima of the two curves do not agree; the level follows the temperature by about four months. It seems, therefore, that the changes of level are not due to the effects of heat directly on the instrument itself, but to an actual movement of some part of the Observatory Hill, in such a position or at such a depth below the surface that the heat of summer and the cold of winter take four months to reach it.

Unfortunately no deep-sunk thermometers have ever been observed here, so that I am unable to say what this depth may be.

From observations at Edinburgh it has been found that the temperature at a depth of 12·8 feet follows the surface temperature by 2⅗ months and at a depth of 25·6 feet by 5½ months. The thermometers there were sunk in the rock which is porphyry. At Greenwich, where the beds were sand and flint-gravel, the numbers were, at 12·8 feet 2⅕ months, and at 25·6 feet 4½ months.

To throw further light on these changes I have examined the records of the level errors of the old transit, which is situated 54 feet to the west of the transit-circle. The changes of level in this case are smaller, and not very easy to follow. Sudden jumps are by no means rare, and there are often long intervals without any determination, but on the whole they follow a law somewhat similar to that of the transit-circle levels.

Up to 1862 the changes are much smaller than in any of the subsequent years. Now, the embankment for the Wellington Railway was completed to Salt River at the end of 1860, and it has been said that the effect of it has been to cause an accumulation of water of much greater extent and longer duration to the north and east of the Observatory than was formerly the case. It may be, therefore, that the present large changes of level are due to the action of heat on the water which has forced its way into crevices and hollows in the hill.

On figure 2 curves are drawn showing the changes of Nadir-point reading and of azimuth in the course of the year. The Nadir-point curve agrees fairly with the temperature curve, but there is a well-marked effect of rainfall in June and July.