

## 29. *Observations of Changes in the Inclination of the Earth's Surface at Mt. Tukuba.*

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The observations of changes in the inclination of the earth's surface at Mt. Tukuba, where a branch of our Institute is situated, were made during 1927—1931 with Ishimoto all-silica clinographs, installed in a windowless stone house built on a natural granite foundation. Several papers on this subject have already been published by W. Inouye, according to which, the changes in inclination are very large, the daily variations in inclination amounting to 1" of arc, and the secular changes to a few seconds of arc. It seems to be a phenomenon largely due to changes in temperature, but further investigations are needed. Although the all-silica clinograph is scarcely affected direct by changes in temperature, it is likely to be affected by changes in inclination of the surface ground caused by fluctuations in temperature due to sunshine and by changes in temperature of the air, etc.. The changes in inclination that we wish to ascertain are not such phenomena but changes of more geophysical significance.

For reducing such temperature effects, a gallery 1 m wide and 2 m high was bored in partially weathered granite, forming a ridge of the mountain on which our branch Institute stands. A boring was made horizontally for a distance of about 25 m from the entrance, and a chamber excavated at the end of the gallery where a fairly fresh granite appeared. To avoid the flow of air, doors were placed in number of places. The plan of the gallery is shown in Fig. 1. For ease of reference we shall call this room "A".

Continuous observations in room "A" were begun in October, 1935. Later, other clinographs were installed at the place near the entrance marked "B" in the figure, and comparative observations were made since November, 1936. In room "A", the changes in inclination were, as expected, so small that the sensibility of the instruments were in-

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1) W. INOUE, *Bull. Earth. Res. Inst.*, 8 (1930), 346; 10 (1932), 130; 11 (1933), 693.

creased so that 1 mm on the record shall correspond to an inclination of about  $0.01''$  of arc.

This paper is a preliminary report of these observations.

Daily variation. In room "A", the magnitude of the daily variation in inclination was of the order of  $0.01''$  of arc, while in room "B" it was of the order of  $0.05''$  of arc, as shown in reproductions of the

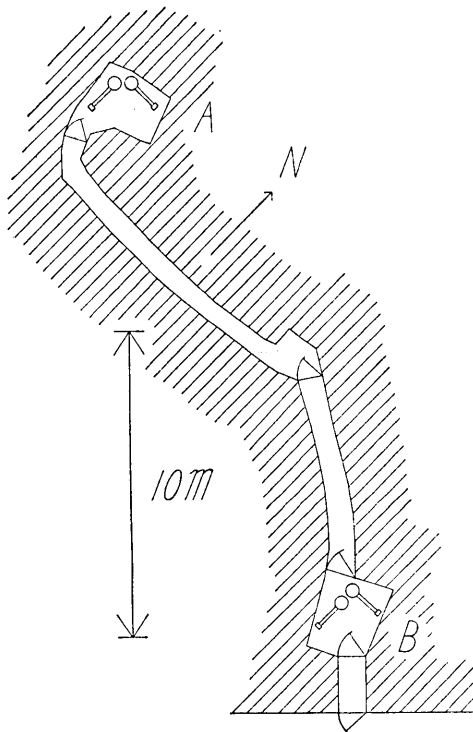


Fig. 1. The plan of the gallery.

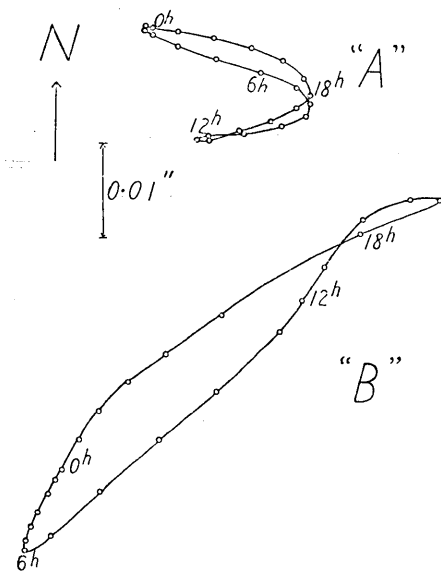


Fig. 2. The mean daily variations.

records in Fig. 4. In room "A", the daily variations have two maximum values in the E-W component and one in the N-S component, while in room "B", the variations have one maximum value in each component. The mean daily variations in rooms "A" and "B" are shown vectorially in Fig. 2. The variations in rooms "A" and "B" differ not only in their quantities but also in their types.

No daily variations with respect to the lunar period could be detected. The variations due to lunar attraction are expected to be of the order of  $0.01''$  of arc, but they could not be detected in the present observations.

Secular variations. The secular variations in inclination are shown

in Fig. 3, in which the mean value for each day is plotted. The variations in room "B" are large compared to that in room "A". However,

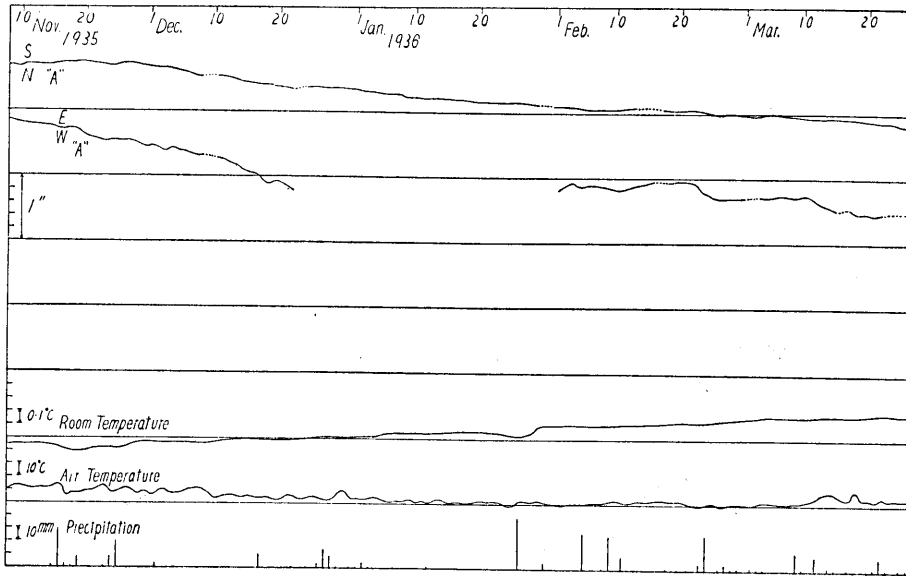


Fig. 3 a.

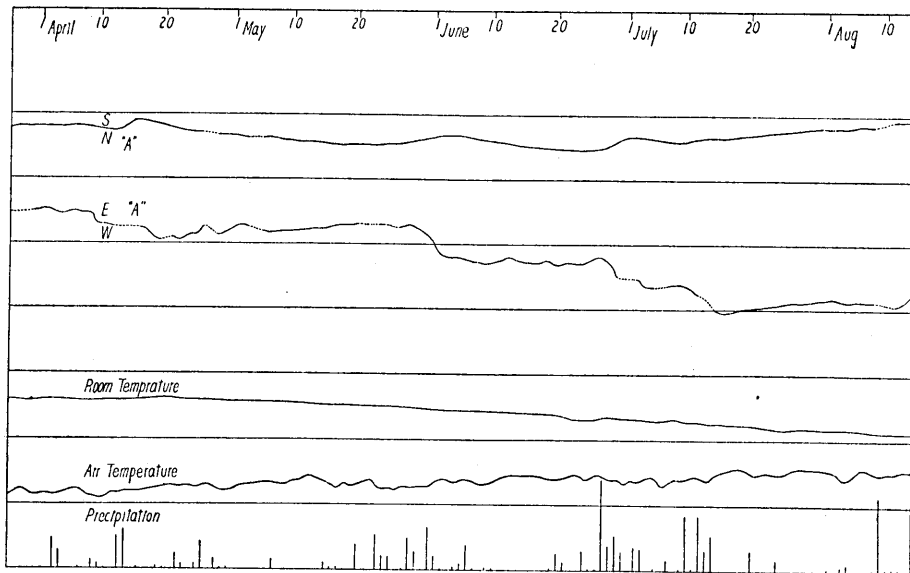


Fig. 3 b.

no correlation between them is evident. For comparison, the temperature of the open air, the temperature of room "A" (which were read

off from a Beckmann thermometer), and the precipitation are also plotted in the figure, from which it will be seen that the annual variation and

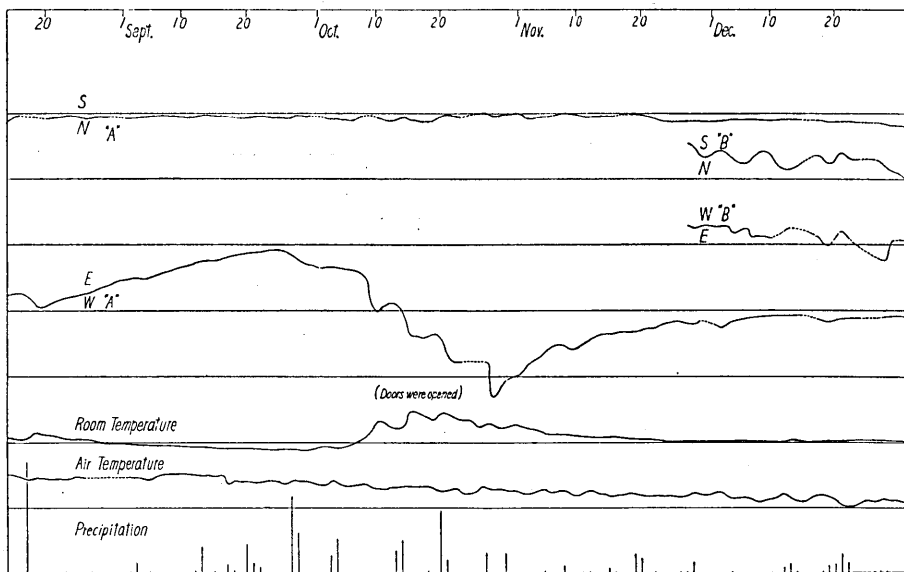


Fig. 3 c.

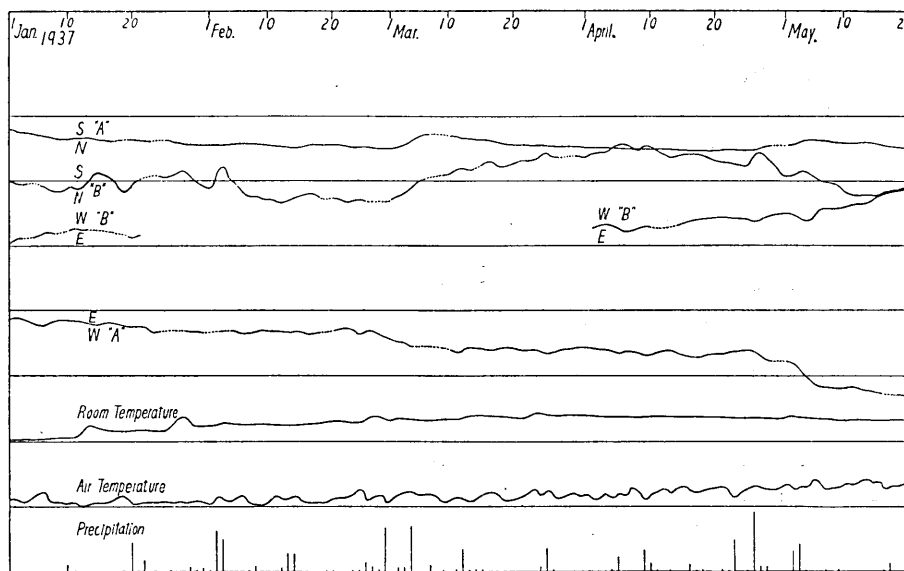


Fig. 3 d.

the large irregular variations in room "A" are intimately related to the variations in room temperature. It was thought that the underground

water might in some way affect the temperature underground, and consequently the temperature of the observation room, but the figures do not show any such relationship between them.

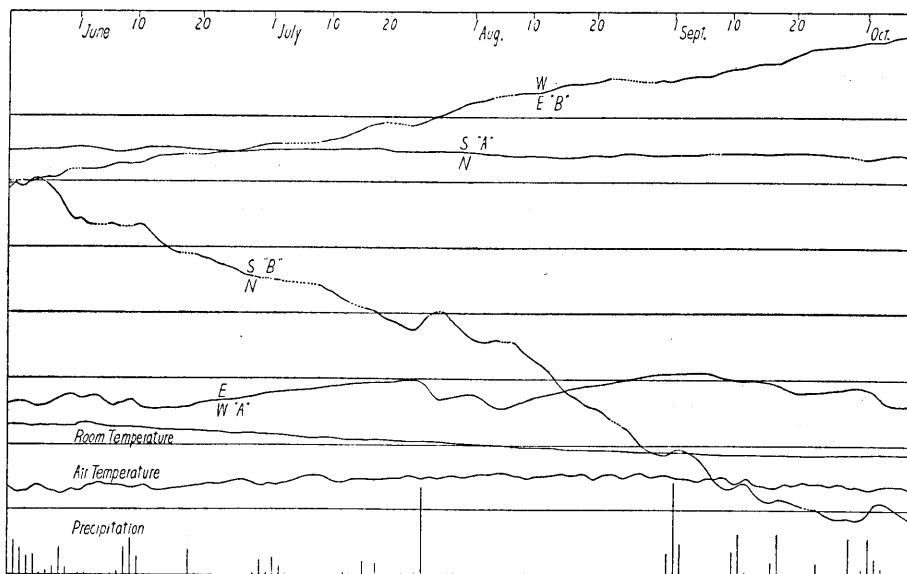


Fig. 3 e.

Remarks. The fact that the changes in inclination in rooms "A" and "B" differ entirely from each other show that measurements of changes in inclination of the earth's surface is a very difficult matter. The changes in inclination are disturbed by irregular changes due to changes in temperature, while relationship between them is in most cases very complicated. We cannot find a simple relation by means of which we could devise ways of eliminating their effects. It is not evident which part of the changes is due to temperature and which part to geophysical causes. So far as our knowledge goes, no such comparative observation has yet been made elsewhere.

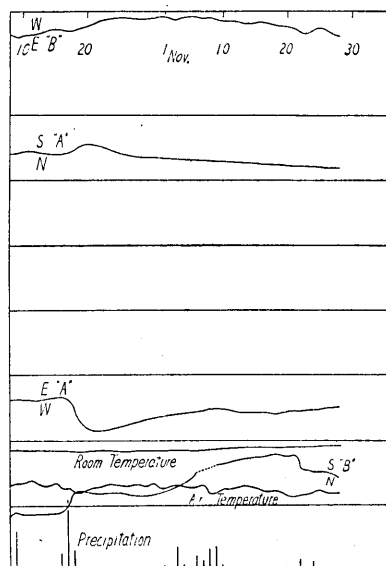


Fig 3 f.

In the cases of such

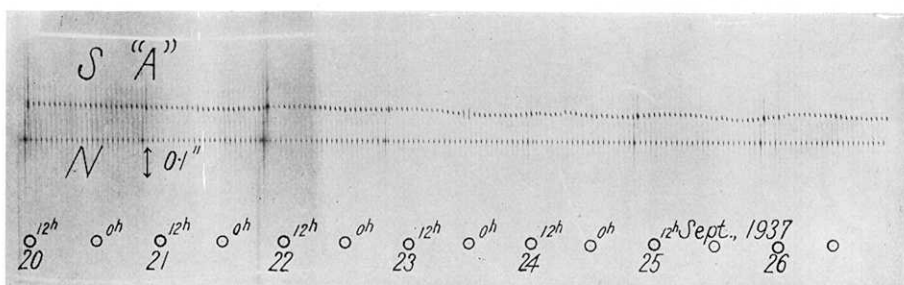


Fig. 4 a.

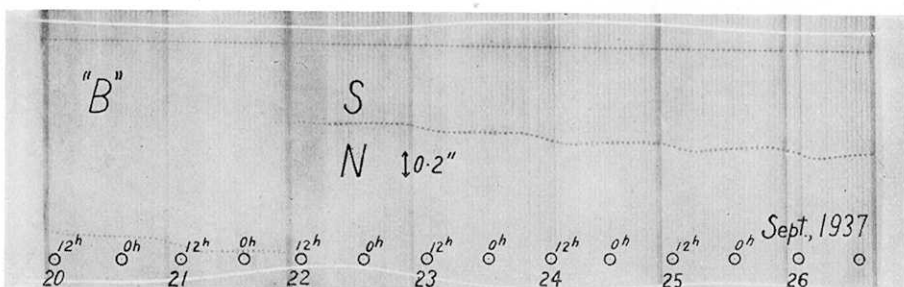


Fig. 4 b.

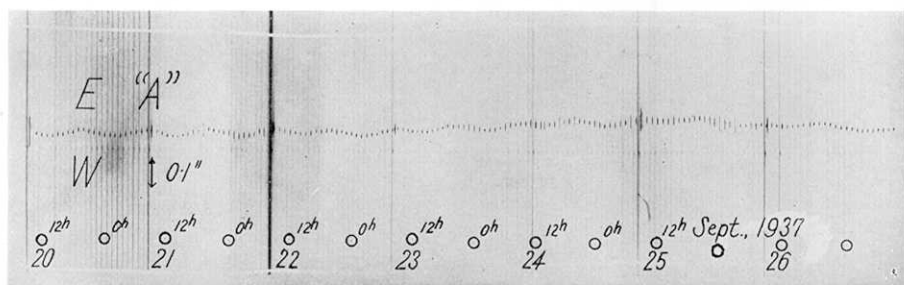


Fig. 4 c.

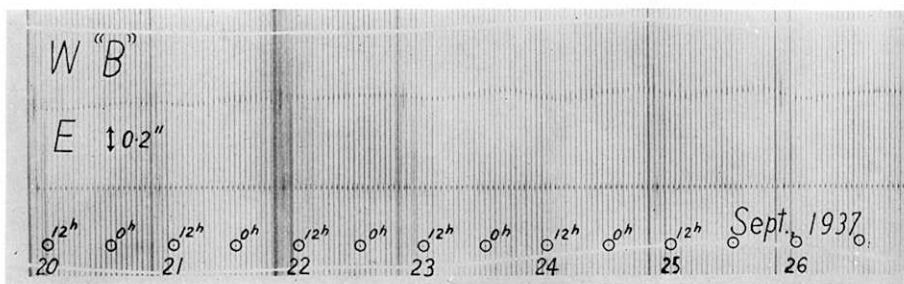


Fig. 4 d.

phenomena, observations at only one place cannot give such macroscopic changes as, for instance, changes in inclination of the *earth's crust*, which question, needless to say, cannot be answered positively from the present observations alone, although it is an important problem worth investigating. This report is preliminary, and does not solve the problem mentioned. The solution will have to await further investigations.

## 29. 筑波山に於ける土地傾斜變化の観測

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筑波山腹にある地震研究所支所に於て昭和 2 年以來約 4 年に亘つて行はれたシリカ傾斜計に依る土地傾斜變化の観測結果は井上理學士に依つて屢々報告せられた。此の観測は自然岩(花崗岩)の一部を切取つて其の上に建てられた抗火石造建物の内部に於て行はれたものである。従つて気温變化の影響を免れ難く、傾斜の日變化の量は 1 秒角にも達し、永久變化は年數秒角乃至十數秒角にも達した。

其後、気温變化の直接間接の影響から免れるため同支所裏手の急斜面に深さ 20 米餘の横坑を穿ち其の最奥に観測室を設けることを試みた。横坑は花崗岩の風化部分を掘進み、餘り風化の進んで居ない部分に行き當つた所に観測室を設けたのである。観測室の温度變化を防ぐため横坑の數箇所に扉を仕切り外部との空氣の流通を遮斷した。観測室の 1 日中の温度變化は極めて少く  $0.01^{\circ}\text{C}$  程度と思はれる。年變化は約  $0.3^{\circ}\text{C}$  である。傾斜観測は昭和 10 年 10 月より開始された。又昭和 11 年 11 月より比較のため横坑の入口に近い場所にも傾斜計を設置し観測を續行して居る。假に横坑の奥の観測室を *A*、入口に近い観測室を *B* と名付ける。

*A* 観測室に於ては傾斜日變化は  $0.01''$  程度であるが、*B* 観測室に於ては  $0.05''$  程度に達する。年變化及び永久變化も *B* 観測室の方が *A* 観測室に比較して遙かに大い。即ち地表近い程日變化年變化のみならず永久變化の量も大である。然も量のみならず其の傾斜方向も *A* と *B* とは一般に共通では無い。斯様に傾斜變化が僅か 20 餘米を距てた兩観測室に於て全く異つた形態を示すこと云ふことは、此の變化が極めて局部的のものであつて廣範圍に亘つて起つた變化では無いことを示すことになる。然し乍ら我々の知らんとする土地傾斜變化は斯様な局部的變化ではなく、地球物理學的に重要性のあるところの、より廣範圍に亘つて一様に現るべき變化である。斯様な比較観測は從來行はれて居ないが、今回の様な現象が若し他の何處に於ても起ると考へたなら單に 1 箇所の観測のみを以てして地殼の傾斜と云ふが如き Macroscopic のものを代表させることは出来なくなるであらう。勿論今回の観測のみを以て斯様な事實を斷定することは出来ないが、將來充分に吟味されて然るべき問題と思はれる。本文は事實を報告して一つの問題を提出するに止まり其の解決は今後の研究を待つものである。