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OBSERVATIONS OF THE SECULAR AND ANNUAL CHANGES OF THE CRUSTAL STRAINS AT OSAKAYAMA

By

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Abstract

The observations of the crustal strains in the directions of *S 38°W* and *S 52°*E at Osakayama with extensometers have been operated, and the secular and annual changes are obtained from these observations.

These observations show that the crust is extended in *S 52°E*, and is contracted in *S 38°W* in the ratios of about 1.6×10^{-6} per year.

This result fully agrees with the result of the trigonometric survey by the Geographical Survey Institute.

1. Observations

The observation of the linear strain of the crust at Osakayama [Ozawa (1959)] has been begun by the leadings of K. Sassa and E. Nishimura in 1947. The observing room at Osakayama is located at *34° 59.6′* of the north latitude and *135° 51.5′* of the east longitude. The instruments are set at sites which are deeper than *60 m* under the ground. The geology is paleozoic system consisted of clay-slate or shale. One component of Sassa type's extensometer whose standard scale is made of super-invar wire [Sassa et. al. (1952)] has set in the direction of *S 38°W* on September *1947*. Thereafter, many components of the other types, extensometers, horizontal type's tiltmeters and water-tube tiltmeters have been set in this observatory.

The secular changes of the crustal deformations observed with two components of the extensometers in the orthogonal directions of *S 38° W* and *S 52° E*. The components in *S 38° W* and *S 52° E* are called R_1 and C_1, respectively. The extensometer in component R_1 has a standard scale which is made of super-invar rod, of which the diameter is *10 mm*, and of which the length is *19.6 m*. Its amplifier is a roller with a reflecting mirror, the recording system is photographic, the optical length being *4m*. The sensitivity is 1.30×10^{-8} per millimeter on the record, and the recording speed is *4* centimeters per day. This instrument was set in *1950*. The extensometer C_1 in *S 52° E* is called H–59–B type[3)]. The standard scale of this instrument is made of super-invar rod which is *10 mm* in diameter and *10 m* in length. The mechanism of this amplifier is that the strain of the base line is transformed into the tilting of the

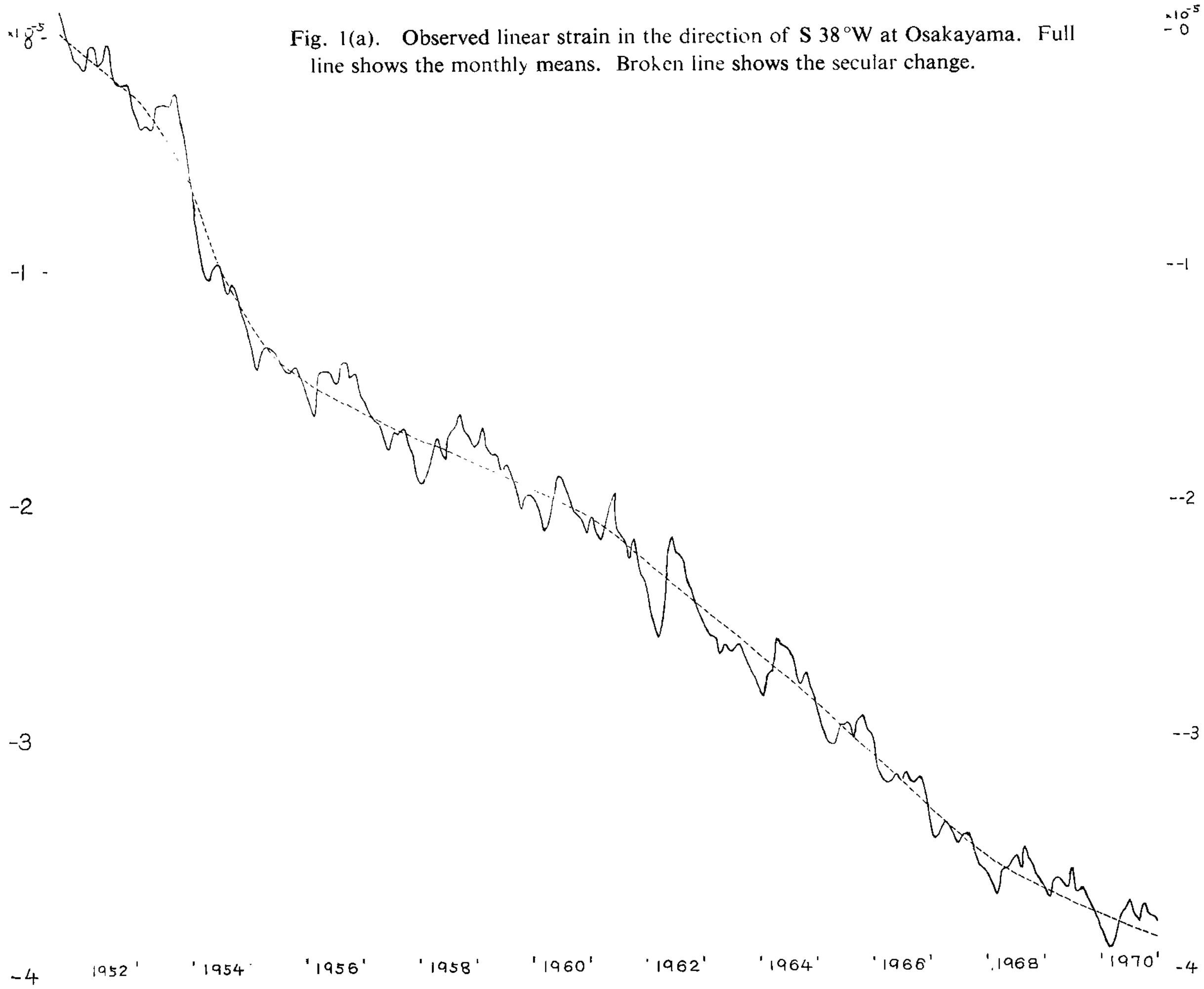

Fig. 1(a). Observed linear strain in the direction of S 38°W at Osakayama. Full line shows the monthly means. Broken line shows the secular change.

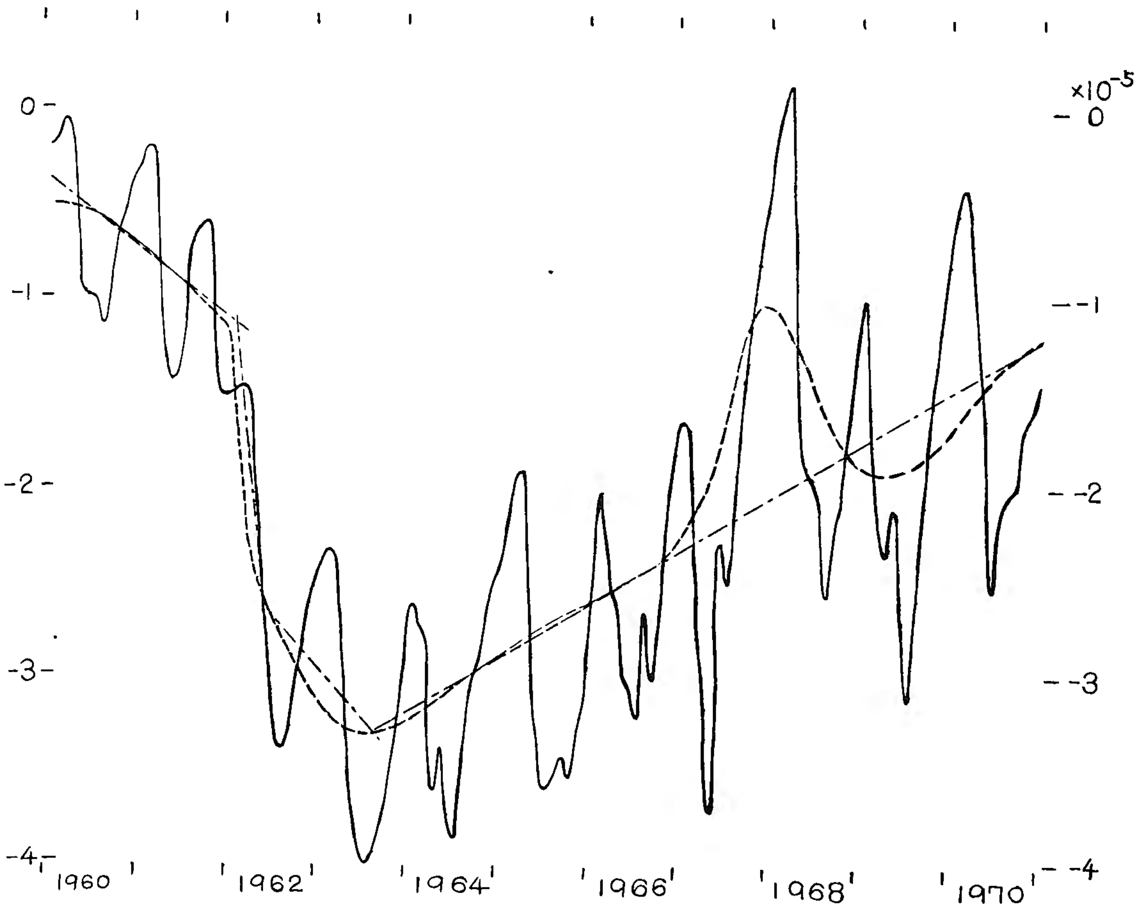

Fig. 1(b). Observed linear strain in the direction of S 52°E at Osakayama. Full, broken and chain lines show the monthly means, the secular change and the linearized secular change, respectively.

axis of the horizontal pendulum, and then the rotation of the pendulum is amplified with the optical lever, and is recorded in the photographic paper. The magnification of of this amplifier system can be adjusted at will to a given value at any time. The range of sensitivity is from 1×10^{-8} to 1×10^{-10} per *1* millimeter. The observation with this extensometer has been operated with the sensitivities of 0.200—$0.060 \times 10^{-8}/mm$ since January, *1960*.

The curves of the monthly means of the linear strains of the crust observed with these instruments are shown in Figs. *1*(a) and (b). We can not calculate a secular change theoretically because a secular change is not usually linear and the annual variations are not generally simple. And so, the secular changes are traced by hand experimentally, and are shown with broken lines in Figs. *1*(a) and (b). The chain line in Fig. *1*(b) shows the linearized secular changes. The velocity of the linearized secular change is 1.66×10^{-6} per year on R_1 for the period from *1955* to *1971*. And the velocities of the linearized secular changes on C_1 are $-1.92 \times 10^{-6}/year$ for the period from February, *1960* to January, *1962*, $-2.75 \times 10^{-6}/year$ for from June, *1962* to January, *1964*, and $1.44 \times 10^{-6}/year$ for from January, *1964* to January, 1971. The mean secular changes are 1.66×10^{-6} per year in the direction of *S 38° W* and 1.44×10^{-6} per year in that of *S 52° E* for these years.

The annual variations which are differences between the monthly means and the secular changes are shown in Figs. *2*(a) and (b). The mean of every annual variations in the direction of *S 38° W* for *19* years shows that the extreme value of contraction is on March, and that of extension on October. These months of the extreme values are in accord to those of temperature in the observing tunnels. The lowest temperature occurs in April and the highest temperature occurs in Octover. The extreme value of extension in the direction of *S 52°* E is on February, and that of contraction is on September. The mean amplitude of this annual variation in *S 52° E* is about 2×10^{-6}, and this value is about three times of that in *S 38° W*. The reason why the amplitude of the annual variation in *S 52° E* is much larger than that in *S 38° W*, is that the length of the extensometer C_1 is much shorter than that of R_1, and C_1 is set in the direction perpendicular to the main tunnels as shown in Fig. *3*.

2. Considerations

The absolute values of the secular changes in *S 38° W* and *S 52° E* are nearly equal and their signs are opposite each other. Assume *S 38° W* and *S 52° E* be the directions of the horizontal main strains. As the signs of the main strains are opposite and the absolute values are equal, the crustal strain consists of a pure shear and a few dilatation. And the crustal strain for the occurrence of earthquake by the breaking is progressing most effectively. If the main strains are put at $-1.66 \times 10^{-6}/year$ and 1.44×10^{-6}/year, and we have that the maximum shear is $3.10 \times 10^{-6}/year$ in *S 38° W*. The accumulated energy in the crust shows rigidity is 2×10^{12} *c.g.s.* is about *10 erg/year* per unit volume (*cc.*). According to this calculation, the total strain energy accumulated

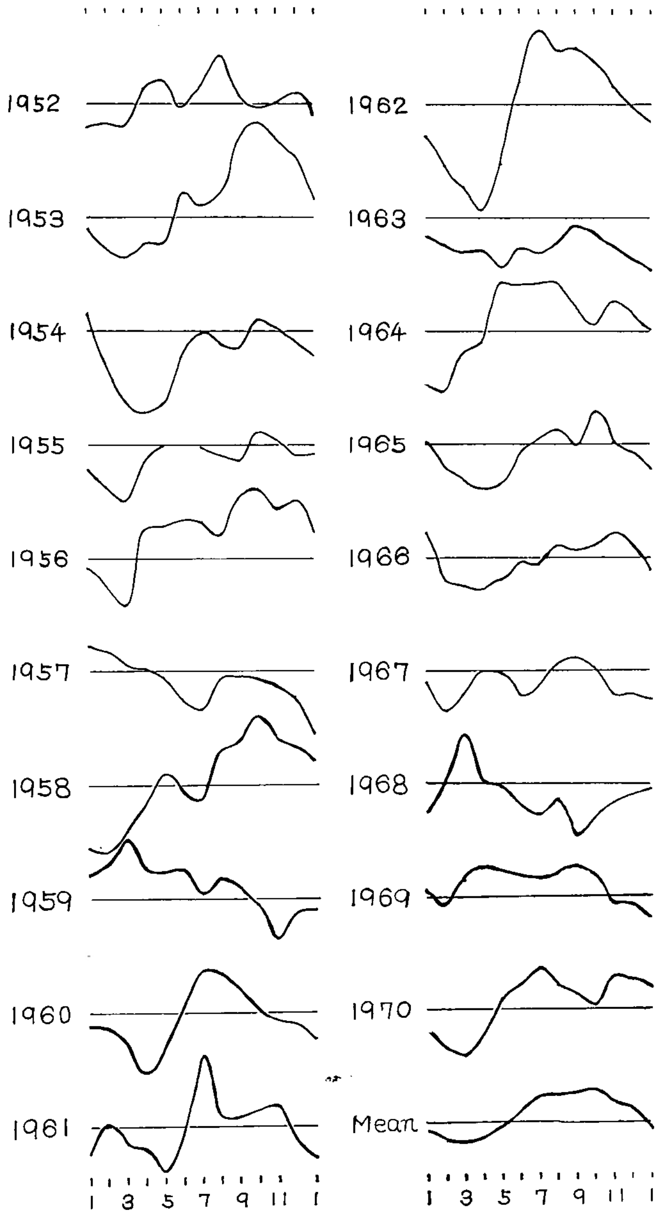

Fig. 2(a). Annual variations of the crustal strain in the direction of S 38°W.

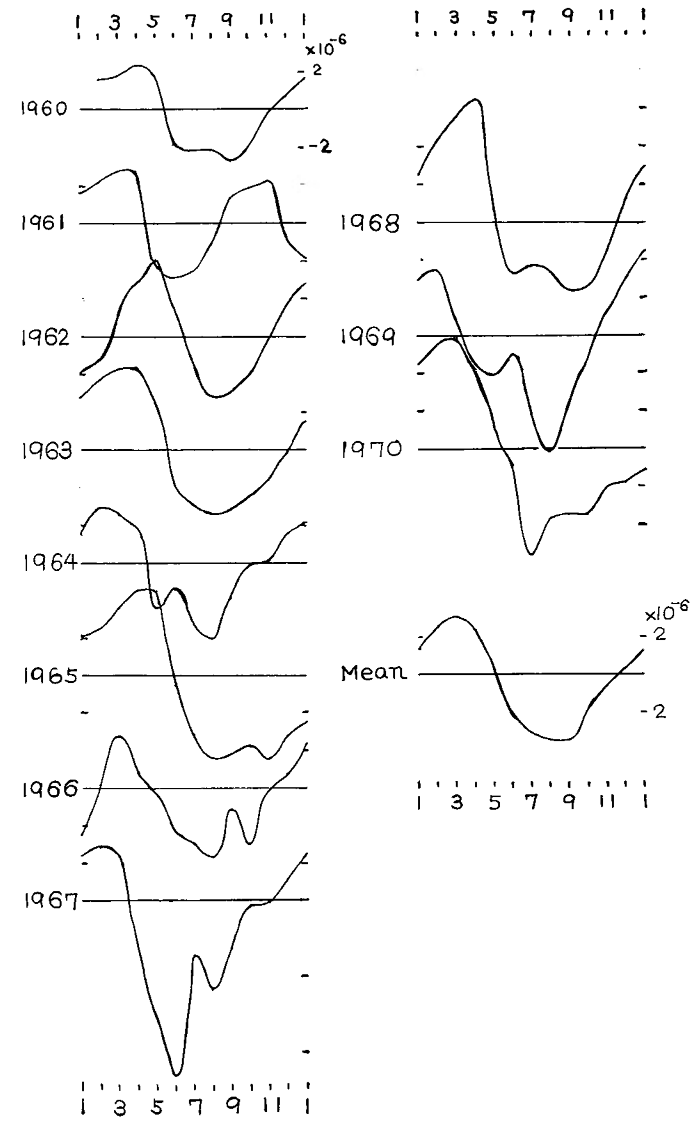

Fig. 2(b). Annual variations of the crustal strains in the direction of S 52°E.

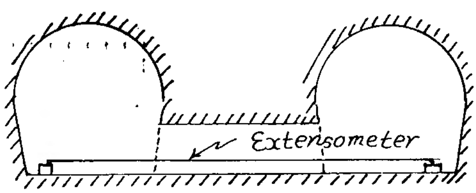

Fig. 3. Setting of extensometer C_1 in tunnels.

for this twenty years is about *200 erg./cc.*, and is about *1/50* of the maximum energy which the crust can stores.

According to the study of K. Harada for the relative displacements of triangulations, these station in the south part of Kinki district have displaced to the east-southwards, and those in the west-north part in this district have displaced to the west-northwards. This result shows that the crust in Kinki district is extended in the south-east direction and is contracted in the south-west direction. However, the magnitude of the mean displacement for this about *40* years obtained by trigonometric

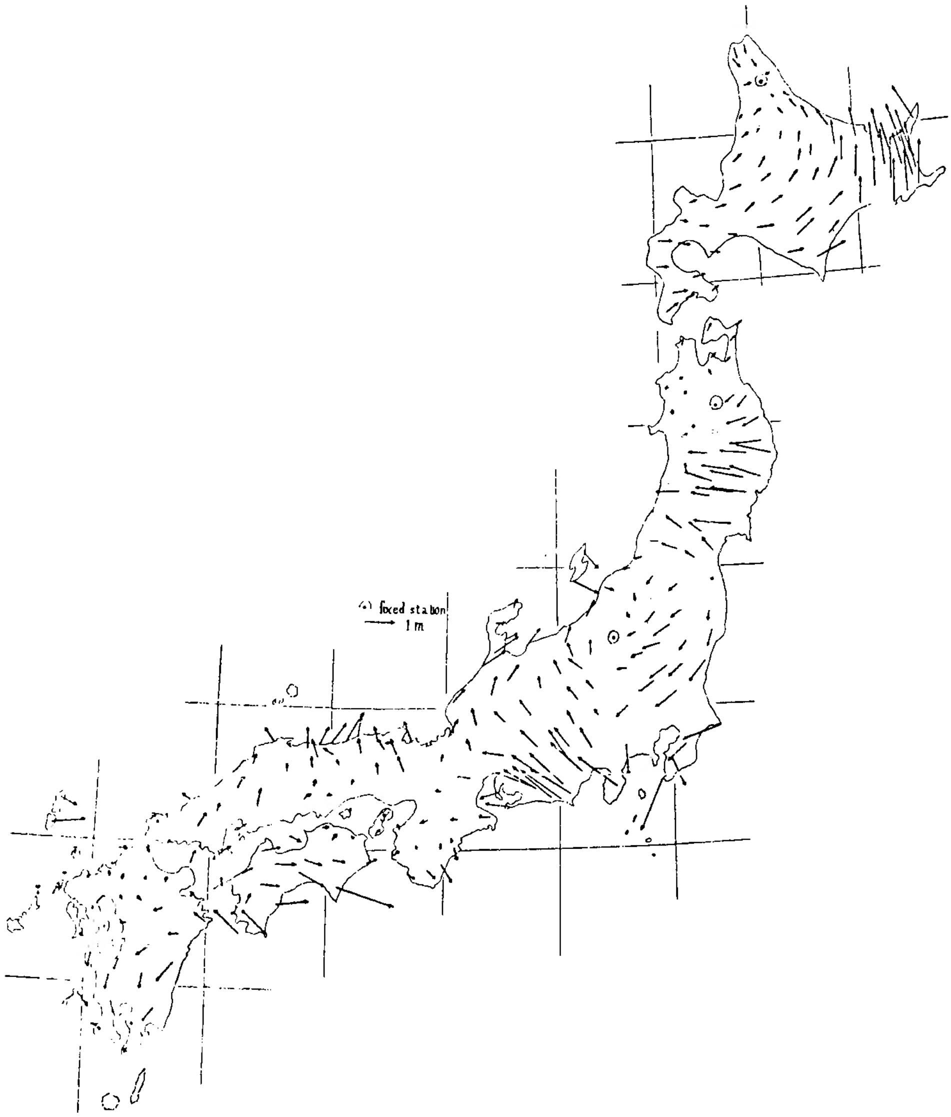

Fig. 4. Relative displacements of trianguration stations (After T. Harada).

survey over this district is about half of our results obtained from the observations of the crustal strains, the signs of the strains agree fully with our results.

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