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Short communication

Long-term variations recorded by extensometers

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On the basis of stress accumulation between two large earthquakes the maximum strain rate can be estimated. We suppose that the rigidity is $\mu = 3 \times 10^{10}$ N/m^2 and for the rock strength we take $p \leqq 10^7$ N/m^2 (Latynina and Karmaleiva, 1978). If the time interval between two big earthquakes is $t = 100$ years, then the maximum strain rate is $p/(\mu t) \leqq 3 \times 10^{-6}$/year. This value could possibly be higher in tectonically very active regions (where t could also be smaller), but certainly not in quiet areas.

To compare this value with the recorded secular rates we compiled Table 1, where the mean secular rates are listed for 28 different stations distributed all over the world. Presently there are about 125 extensometric stations in operation (Bilham, 1973). The data presented in Table 1 can be assumed to characterize the whole network. The records used usually cover a period of more than 1 year. (An exception is the series recorded by Berger and Levine (1974) in the Poorman mine with a laser strainmeter, which cavered only 9 months.) The mean of the secular rate values is 2.1×10^{-6}/year. A rough estimation of the horizontal crustal movements resulting from this value is 2.1 mm/year in 1 km, a value which can be measured by geodetic techniques. For a Young's modulus of $(8–12) \times 10^{10}$ N/m^2 (Latynina and Karmaleiva, 1978) the corresponding stress rate is $(1.7–2.5) \times 10^5$ Nm^{-2}/year.

There is a tendency in the literature to interpret such "secular strain rates" (determined with extensometers) tectonically. The question arises whether this is possible. We must remember that the values in Table 1 were determined at different times, with different types of instruments. The strainmeter used had different orientations and, what is more, in the case of stations where observations were carried out in different azimuths their mean value was used.

Table 1. Average secular strain rate values

Continent (Country)	Station	Type of extensometer	Secular rate of strain $\times 10^{-6}$/year		Reference
North America					
USA	California	Q		1.0	Benioff, 1959
	Odgensburg	Q		0.1	Beavan and Bilham, 1979
	Poorman mine	L		0.6	Berger and Levine, 1974
	La Jolla	L		0.2	Berger and Wyatt, 1973
	Nevada	Q		2.0	Priestley, 1974
	Pinon Flat	L		0.3	Wyatt and Agnew, 1983
	Aleuts	Q		3.0	Butler and Brown, 1972
			Mean	1.0	
Europe					
Great Britain	Yorkshire	W		0.2	Bilham et al., 1972
		L		0.7	Goulty et al., 1974
		W		5.0	Beavan, 1976
		W		5.0	Evans et al., 1979
GDR	Tiefenort	W		2.2	Harvardt and Simon, 1974
FRG	Schiltach	W		10.0	Kind and Emter, 1974
Hungary	Budapest	Q		2.0	This paper
USSR	Protvino	Q		0.5	Latynina, 1975
	Tbilisi	Q		4.0	Latynina and Karmaleiva, 1978
			Mean	3.2	

Table 1 (continued)

Continent (Country)	Station	Type of extensometer	Secular rate of strain $\times 10^{-6}$/year	Reference
Asia				
Japan	Osakayama	W	2.0	Ozawa, 1971
	Amagase	W	1.2	Takada et al., 1981
	Kamigao	W	4.0	Nishimura et al., 1959
	Esashi	Q	0.2	Sato et al., 1983
	Erimo	W	0.2	Kasahara, 1981
USSR	Talgar	Q	1.0	Latynina, 1975
	Garm	Q	0.5	Latynina, 1975
	Turgen	Q	6.0	Ospanov et al., 1981
	Tschusal	Q	1.5	Latynina and Karmaleiva, 1978
	Inguri	Q	2.0	Latynina and Karmaleiva, 1978
			Mean 1.8	
Australia Oceania				
Australia		Q	2.0	Sydenham, 1974
New Zealand		W	5.0	Gerard, 1973
			Mean 3.5	
			Mean of all measurements 2.1	

Q – quartz extensometer; W – wire extensometer; L – laser extensometer

In spite of these limitations we can conclude that secular rate values of the order of 10^{-6}/year cannot be simply connected with the degree of tectonic activity. The lowest values in Table 1 cannot be so easily discarded for tectonic interpretation, but the non-tectonic sources of the larger strain rates should be clearly understood before such an interpretation is made. Long-term variations at stations in Asia (all of which are in the tectonically most active areas) are similar to the ones observed in Europe, where the majority of the stations are in quiet regions. It can also be easily concluded that almost everywhere – regardless of the tectonic conditions – the long-term variations have values which are very close to the extreme rate expected.

It is necessary to add that the influence of external forces (meteorological, hydrological) on the long-term part of the strainmeter record – in the case of appropriate installation – are of secondary importance. According to the author's experience with a 21-m-long quartz tube extensometer installed in a 35-m-deep station in Budapest, the annual variations of the record are 10^2 times smaller than the secular rate. The influence of barometric and water table variations is even less.

It can be concluded that the strain rates cannot be used to estimate directly the magnitude of the tectonic processes. The estimates of stress rates and horizontal crustal movement values are bigger than the real values in nature.

Due to the significant differences among stations situated in the same region it seems that secular rates are modified or increased to a considerable extent by local conditions of different type, which are not connected to tectonic activity.

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