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The Location of Earth Strain Instrumentation

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The location of Earth strain instrumentation

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A list of strainmeter locations is presented. The geographical coordinates and instrumental parameters of more than 250 instruments are summarized together with information concerning altitude, depth below ground level and rock type.

The following pages are a partial summary of the response to a questionnaire circulated in 1969 by the Royal Society concerning the study of small-scale movements of the Earth's crust. The questionnaires were sent to the national committees of all countries corresponding to the International Association for Geodesy and several hundred replies were received. The purpose of the questionnaire was to ascertain the extent and sophistication of precise measurements of crustal movements. The replies ranged from geodetic triangulation and trilateration work to the development and application of instruments for the measurement of tilt, strain and gravity. Much of the work described has advanced since then and new techniques have evolved, especially in the field of long-distance geodetic work. It would not be possible to do justice to the present wide range of precise geodetic work and so it has been omitted from this summary. However, it is possibly of interest to many to learn of the large number of locations in which tilt and in particular strain are being measured. The reader interested in the distribution of observatories where tilt and gravity measurements are taking place is referred to Melchior (1969). A summary of the location of Earth strainmeters is presented. However, it should be remembered that the commendable move towards locating these instruments in non-observatory environments to study 'real geophysical problems' must inevitably mean that the list is largely incomplete.

Key to strainmeter location list

Latitude is in most cases north except where stated. Likewise longitude is measured eastward. The third column shows the altitude of the strainmeter above mean sea-level and the fourth column the depth below the surface of the ground. A date in the fifth column indicates the year in which the observations started or, in some cases which are in italics, the year in which operation ceased. The sixth column indicates the rock type in which the strainmeter is installed. The final column summarizes the strainmeter characteristics.

Key to strainmeter description

Four parameters are coded to describe the type of strainmeter. The *type* of length standard used is always the *second* code letter in the type designation. (Five types of length standard are mentioned.) It is preceded by a figure which specifies the number of instruments and is followed by a figure in parentheses which indicates the length of the strainmeter. If several figures are shown in parentheses these are the different lengths of separate strainmeters where known. The third parameter describing the strainmeter is the type of transducer; six types of transducers are mentioned. The last parameter is the method of recording. In addition, the azimuth is given where it is known for single strainmeters.

Strainmeter sensitivity is adequate in nearly every strainmeter listed to measure strains smaller than 10^{-9} strain. Exceptions are stated where these are more or less sensitive.

Strainmeter description (last column)

sequence	A	B	(C)	D	E
example	2	Q	(20)	C	i

interpretation: two 20 m quartz rod strainmeters with capacitive transducers and paper chart recorders.

A *number of strainmeters* (altogether, more than 250 instruments are mentioned)

B *type of length standard*
- Q, fused quartz
- I, invar rod
- S, suspended wire (variable sag, Sassa type)
- W, constant tension wire
- L, laser

C *length of strainmeter(s)* in metres

D *type of transducer*

laser strainmeters
- Mc, Michelson interferometer with fringe counter
- Mf, Michelson interferometer with fringe follower
- Ff, Fabry Perot with fringe follower
- Fb, Fabry Perot with beat frequency counter.

solid length standard strainmeters
- C, capacitative displacement transducer
- E, electromagnetic displacement transducer
- P, photocell transducer
- R, roller type amplification
- O, Ozawa type zollner amplification
- B, bifilar transducer

E *type of record*
- p, photographic, direct optical level or galvanometer
- i, pen chart recorder, ink, scratch or heated stylus
- t, punched or magnetic tape

		latitude	longitude	altitude	depth	start or end date	rock type	strainmeter description
	Japan							
1	Abaratsubo	35 09	139 37	3	12	1960	sandstone	3Q(8, 10, 25)–i
2	Akibasan	34 11	135 10	10	15	1960	—	1I(–)Bp
3	Aobayama	38 15	140 51	—	—	1967	sandstone	1Q(–)Ei
4	Bessi	33 52	133 19	650	750	*1949*	—	1I(24)Bp
5	Donzuroba	34 32	133 19	150	30	1961	—	7I(–)Rp
								2S(–)Bp
								3Q(–)OpRiCt
6	Fujigawa	35 14	138 25	—	—	1970	conglomerate	3Q(40)Eip
7	Hosokura	38 48	140 54	130	160	’44/57	—	1S(20)Bp N55W
8	Himekami	39 51	141 15	—	—	1970	granite	1Q(–)Ep
9	Hokushin	36 42	138 12	—	—	1968	tuff	3Q(40)Rp, i
10	Ide	34 48	135 49	150	30	1952	mica schist	8I(–)Rp
								3I(–)Op
								1I(–)Ep
		34 54	135 50	—	—	1967	Palaeozoic	7I(–)Rp
								1S(–)Bp
11	Iwakura	35 05	135 48	280	50	1961	Palaeozoic	3I(–)Rp
12	Izu nagoaka	35 20	138 56	50	25	1968	Tertiary	2I(5, 4)Bp
13	Kamigano	35 04	135 46	190	9	1957	Palaeozoic	1I(5)Bp, N25E
14	Kamitakari	36 17	137 19	800	40	1966	granodiorite	3Q(28)–, p, i
15	Kishu	33 52	135 53	50	100	1963	Tertiary sandstone	2I(–)Op
								3S(9, 8, 5)Bp
16	Kochi	33 34	133 32	10	40	49/53	—	1S(24)Bp, N14W
17	Mekamine	32 37	131 27	130	165	49/52	—	1I(20)Bp, N57W
18	Makitani	35 56	136 13	0	10	1969	rhyolite–andesite	4-(10, 9, 8, 6)Ei
								3I(8)Bp
19	Matsushiro	36 33	138 13	440	60	1953	diorite–porphyry	2S(25)Bp
								1Q(100)Rp, Ci
20	Matsutama	33 50	132 43	5	10	1947	shale	3Q(25)Rp
21	Maize	37 40	138 48	5	10	1952	tuff	2Q(11)–p
22	Miyako	39 35	141 59	—	—	1969	granodiorite	1Q(–)Ep, i

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		latitude	longitude	altitude	depth	start or end date	rock type	strainmeter description
23	Nibetsu	39 48	140 16	—	—	1967	granite	1Q(–)Ep, i, t
24	Mitsubishi	35 40	135 47	500	200	1943	—	1S(25)Bp, E3S
25	Nagashima	34 13	136 13	800	80	1961	Palaeozoic	1S(30)Bp, N/S
26	Nokogiriyama	35 10	139 50	23	10	1960	tuff	3Q(25)–i
								1–(1.5)Ei
27	Oga	39 54	139 47	—	—	1967	quartz–andesite	-Q(–)Ei, t
28	Ogoya	36 17	136 33	210	300	1948	Tertiary tuff	1S(20)Bp, N48W
29	Osakayama	34 59½	135 51½	100	150	1949	—	6I(–)Op
								7S(–)Bp
30	Oura	34 11	135 10	50	10	1960	—	2S(5)Bp
31	Sakuma	35 06	137 48	132	20	1956	granite	3Q(18, 9, 10)Rp
32	Sanriku	39 06	141 46	—	—	1969	shale	–Q(–)Ep, t
33	Shima	34 22	136 48	25	10	1961	Pliocene	1I(5)Bp, N65E
34	Shionimisaki	33 27	135 46	10	5	1957	—	—
35	Suhara	33 52	135 53	—	—	1963	Palaeozoic	3Q(–)Op
36	Susaka	36 38	138 19	450	30	1966	porphyrite	3I(5, 5, 2.5)Bp
37	Tottori	35 31	134 16	150	100	1958	—	1I(5)Bp, N35W
38	Yahiko	37 44	138 40	30	50	1957	tuff	3Q(30)–p, i, t
39	Yokoyama	—	—	—	—	*1888*	—	iron (1) lever
40	Yura	33 57	135 07	10	30	1957	Mesozoic	4I(5, 5, 6, 2)Bp
	Asia							
41	Garm, Tadzhikstan	39 04	70 23	—	—	1968	—	Q
42	Serpoukhov, Moscow	37 36	54 42	145	15	1965	—	—
43	Kondara (Dzherino), Tadzhikstan	38 48	68 49	1100	45	1964	—	3Q(18)RpPi
44	Talgar, Kazakstan	43 16	77 23	1800	50	1961	—	2Q(20)Rp
45	Tbilissi, Georgia	41 50	44 57	500	60	1962	—	2Q(41, 14)
46	Yalta, Crimea	44 40	34 12	10	4	1956	slates	1Q(2)Rp
47	Dasht-e-Bayaz, Iran	34 10	58 30	1500	9	1971	conglomerates	3W(10)Ei, N54W
	U.S.A.	lat. north	long. west					
48	Amchitka S.E.	51 22	179 13	95	0	1969	—	3Q(–)Ci, $10^{-5, -6}$
49	Amchitka N.W.	51 38	178 40	650	0	—	—	3Q(–)Ci, $10^{-6, -7}$
50	Adak	51 53	176 41	360	0	—	—	3Q(–)Ci, 10^{-7}
51	Bergen Park	39 42	105 12	—	—	—	—	3Q(–)Ci
52	Boulder, Col.	40 00	105 23	1882	55	1967	granite	1L(30)Fb, $10^{-8, -13}$
53	Blacksburg	37 14	80 25	635	—	1967	—	—
54	Cascades, Wash.	47 47	120 50	—	500	1968	granite	1L(1020)Ff, $10^{-8, -11}$
55	Dalton Canyon	34 18	117 49	523	—	1957	—	1Q(24)B, Ci
56	Denver, Col.	39 52	104 49	—	0	1967	—	—
57	Elliot, Cal.	32 53	117 06	—	0	1969	stiff clay	1L(800)Mc, $10^{-8, -11}$
58	Flat River, Mo.	37 50	90 29	180	110	1969	dolomite	3Q(30)Ci
59	Franklin	41 05	76 36	—	—	1956	—	1Q
60	Garland	32 52	96 40	183	14	*1968*	limestone	1I(18) vertical
61	Green Abs, Col.	—	—	—	—	—	—	Q–
62	Hollister	36 38	121 14	—	0	1968	surface	1Q, 10^{-2}, several creep
63	Houlton, Maine	46 10	67 59	213	14	1969	slates	1I(18) vertical
64	Isabella, Cal.	35 40	118 29	835	50	1957	granite	1Q(30)Ci, N23W
65	Kernville, Cal.	35 40	118 29	860	100	1966	granite	2L(25, 10)Ff
66	Kipapa, Hawaii	21 25	158 01	—	25	1964	basalt	1Q(24)Cp
	Nevada nuclear test range (stations 67–80)							
67	Yucca Mtn	36 56	116 33	1341	3	1970	welded tuff	1I(6)Ci
68	Sleeping Mtn	37 09	116 46	1400	2	1969	—	3Q(6)Ci
69	Scottys Junction	37 05	117 16	1400	2	1969	—	1Q(9)Ci, N84E
70	Triaxial	37 08	116 02	1280	2	1969	alluvium	3I(6)Ei
71	914M	37 08	116 05	1328	2	1969	alluvium	2I(6)Ei

		latitude	longitude	altitude	depth	start or end date	rock type	strainmeter description
72	1524M	37 08	116 06	1334	2	1969	alluvium	2I(6)Ei
73	Thirsty Canyon	37 12	116 34	1700	2	1969	—	4Q(6)Ci
74	Oak Spring Butte	37 14	116 03	1731	40	1970	limestone	1Q(6)Ci, N81E
75	—	37 14	116 09	1800	500	1968	—	3Q(6)Ci
76	Tolicha Peak	37 17	116 52	1524	3	1970	tuff, rhyolite	1Q(6)Ci
77	Quartzite Mtn	37 33	116 19	1874	4	1970	volcanics	1Q(6)Ci, N20E
78	Kawich Peak	37 54	116 28	2134	8	1970	volcanics	1Q(6)Ci, N4W
79	Rawhide Mine	38 14	116 23	1768	5	1970	metasediment	1Q(6)Ci, N35W
80	Twin Springs	38 12	116 09	2200	2	1969	—	3Q(13)Ci
81	Ely	39 16	114 57	2200	2	1969	—	1Q(32)Ci
82	Ogdensberg, New Jersey	41 05	75 36	−370	543	1960	coarse marble	4Q(60)Ci 1L(1)Mc, shear strair
83	Pasadena	—	—	—	—	1935	granite	iron(20)Ep
84	Stone Canyon, Nev.	36 38	121 14	300	2	1967	Miocene sediment	3Q(30)Ci
85	Salt Lake, Utah	40 34	111 46	2000	300	1968	granite	3Q(33, 33, 10)
86	Queen Creek, Arizona	33 11	111 38	610	110	1970	quartz diorite	3I(40, 40, 12vert)
87	Wichita Mtn, Oklahoma	34 43	98 35	455	4	63/69	granite	6Q(18)Ci
	South America	lat. south	long. west					
88	Arequipa, Peru	16 44	71 34	2300	20	1965	—	—
89	Ayanquera, Peru	17 01	71 40	250	22	1965	—	—
90	Chosica, Lima, Peru	—	—	—	—	1957	—	1Q(25)Ci
91	Condor, Peru	13 54	75 32	1550	—	1965	—	—
92	Guadalupe, Peru	14 00	75 48	550	20	1965	—	—
93	Nana, Peru	11 59	76 51	580	—	1957	—	2Q(30)Ci
94	Ongoro, Peru	15 89	72 28	900	25	1965	—	—
95	San Christobal, Santiago, Chile	—	—	—	—	1957	—	1Q(25)Ci
96	San Gregorio, Peru	16 56	72 42	140	20	1965	—	—
97	Saramarca, Peru	14 50	75 06	840	60	1965	—	—
98	Zamaca, Peru	14 67	75 36	300	20	1965	—	—
	Australasia	lat. south	long. east					
99	Cooney Tunnel, Armidale, N.S.W.	30 35	151 53	—	200	1971	—	2W(10)Ei IQ(10)Ei
100	Brisbane, Australia	28 30	153 00	—	47	1966	—	1L(3)Mc, shear
101	Wellington, New Zealand	41 18	174 44	380	10	1970	greywacke	3W(10)Ei
	Europe	lat. north	long. east					
102	Bonn, Germany	50 35	07 14	—	80	1972	basalt	1W(10)Ei
103	Burdale, G.B.	54 03	00 40W	130	80	1971	chalk	1W(10)Ei, N34W
104	Braunschweig, Germany	65 40	17 00	—	—	—	—	—
		64 10	21 10	—	—	—	—	—
105	Cambridge, G.B.	52 12	00 07	30	0	1971	clay	2W(10)Ei N2E
106	Clayton, G.B.	53 46	01 50W	200	80	1972	shales	1W(10)Ei N67E
107	Freiberg, D.D.R.	50 55	13 20	385	1	1961	—	1Q(25)Ei, N36W
108	Genoa, Italy	44 25	08 55	58	18	1967	schist	2Q(12)Ei, N36W
109	Moxa, D.D.R.	50 39	11 37	455	—	1969	—	2Q(–)Ei
110	Paris, France	48 50	02 20	50	—	1961	—	1Q(10)OpCi
111	Queensbury, G.B.	53 46	01 51W	200	120	1969	sandstone and shales	1L(54)Mc N45E 6W(10)Ei N45E 1Q(20)Ei N45E

		latitude	longitude	altitude	depth	start or end date	rock type	strainmeter description
.2	Schiltach, Germany	48 18	08 17		120	1972	granite	4W(10)Ei
.3	Trieste, Italy	45 41	13 47	180	15	1970	limestone	1L(60)Mc 1W(10)Ei
.4	Walferdange, Luxembourg	49 40	06 09	372	100	1971	gypsum	1Q(3)Ci, vertical 1Q(25)CiOp 1I(15)Op 3W(10)Ei
.5	Woodhead, G. B.	53 30	01 48W	300	200	1972	sandstone	1W(10)Ei N59E

Reference (Bilham)

Melchior, P. 1969 *Bulletin d'Information Marées Terrestres*, No. 56, 31 December 1969. Observatoire Royale de Belgique, Bruxelles 18.

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