CONSTRAINTS ON TECTONIC DEFORMATION IN THE SOUTHERN ALASKA SUBDUCTION ZONE FROM HISTORICAL SEISMICITY

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General Purpose and Background

The purpose of the project is to reassess the historical seismicity of the Central part of Alaska. This area, which in principle, should be considered intraplate, is the site of significant seismicity, leading to the possibility of a diffuse plate boundary, such as has been documented elsewhere, for example in the Indian Ocean.

In particular, the central part of Alaska features intriguing historical earthquakes, for which magnitudes as large as $M = 7.3$ have been proposed. As always the case when dealing with historical events, the location, size, depth and focal geometry of these events are generally imprecise, and must be carefully re-assessed with the full power of modern day seismological techniques. What makes this endeavor particularly crucial is the regular operation of a VLBI station at Fairbanks in the immediate vicinity of the reported epicenters of major earthquakes in 1937 and 1947. It is generally assumed by Space Geodesists that Fairbanks, several hundred km North the plate boundary, is firmly anchored to the North American continent, and can be viewed as a genuine sampling of the stable North American plate.

Investigations Undertaken and Results Obtained

We have undertaken to study approximately 30 historical earthquakes, with dates ranging from 1916 to 1960†. These events were selected on the basis of having at least one magnitude reported as $M \geq 7$, in various catalogues including the NEIC tape and the International Seismological Summary [ISS]. Our investigation is directed along several fronts: (i) relocation of the earthquakes; (ii) reassessment of their size; and (iii) evaluation of their focal geometry.

- *Relocation*

The basic dataset for relocation consists of the arrival times listed in the ISS. Because the ISS starts reporting systematically around 1915, our first event goes back to 1916. We use a computerized iterative algorithm, satisfactorily developed in previous investigations (and applied to many hundreds of events) by the investigators. The algorithm can improve the old ISS locations for two fundamental reasons: we include S times, which the ISS lists, but does not use in locating; and the computerization of the process allows us to test, identify, and eventually reject data of lower quality, which either prevent convergence, or result in excessive standard

† "Historical" earthquakes have traditionally been taken as those predating the establishment, in 1963, of the World Wide Standardized Seismographic Network, which for the first time allowed the routine and precise location of earthquake foci worldwide.

residuals. In addition, we conduct statistical tests of the solution, by artificially injecting noise into the data, and studying its influence on the resulting locations.

In general, the 29 events relocated by this procedure were not significantly displaced from their original locations (an average of 40 km). In several instances, we were able to obtain some constraints on depth, and in the case of the 1916 event, suggest that the earthquake is probably shallow.

Probably the most important result of this part of the investigation is that the large earthquakes of 1937 and 1947 in the vicinity of Fairbanks actually took place South of the city; indeed, both events relocated South of their original epicenters. This crucial result validates the assumption, tacitly used in Space Geodesy, that no large scale crustal deformation takes place between Fairbanks and the bulk of the North American continent, in other words that Fairbanks does represent a stable benchmark in the North American plate.

- *Magnitudes*

An attempt was made to reassess the magnitudes of some of the more significant events in the dataset. A large collection of records were inspected, and when feasible, digitized at the University of Uppsala, Sweden, which maintains one of the best archives of Wiechert seismograms; at the Caltech archives in Pasadena; and at the USGS Historical Seismogram Facility in Denver. In many cases, standard surface wave magnitudes appear to have been overestimated (see Table 1). We are presently researching the origin of this bias, which may lie in the use of a variable period in the early magnitude measurements.

Whenever possible, we conducted a measurement of the mantle magnitude M_m, measured at very low frequencies, and representative of the seismic moment of the source, as introduced by us in earlier investigations. Given the above remark regarding M_s, the generally lower than expected level of the seismicity resulted in only a small number of M_m values: there was just not enough energy at long periods in most old records to obtain a reliable measurement (see Table 2).

- *Focal Mechanisms*

We are presently investigating the focal mechanism of the central Alaskan events of 1937 and 1947. Because of the paucity of records available for this study, we have to rely on special techniques. We are using the three-component Benioff 1-90 records at Pasadena, which have the double advantage of providing good recording characteristic throughout a broad frequency spectrum, and of having been continuously used up to the present, allowing for direct comparison with modern earthquakes. Since the historical events were not truly gigantic, their spectrum is concentrated in the 20–70 s period range, in which the influence of lateral heterogeneity on the dispersion characteristics of surface waves is primordial. In order to eliminate this unknown parameter, we use modern earthquakes traveling over a similar path (Northwestern Alaska to California), and whose focal solutions have been published as part of the CMT dataset, in order to retrieve the Love and Rayleigh dispersion along the source-to-receiver path, and in turn extract the focal parameters of the historical earthquake (moment and geometry) from the complex spectra of its Love and Rayleigh waves at a single station. This work is presently being performed with Graduate Student Wei-chuang Huang.

Table 1: Alaskan Historical Earthquakes Relocated in This Study

Date	Initial Location					Relocation				
D M Y	Time (GMT)	Lat. °N	Long. °W	Depth (km)	M	Time (GMT)	Lat. °N	Long. °W	Depth (km)	M_s (UPP)
18 4 1916	04:01:48.0	53.25	170.00	170	7.5	04:01:44.9	53.66	170.00	33.0	
04 5 1923	16:26:39.0	55.50	156.50	25	7.1	16:26:42.2	55.29	156.67		
24 10 1927	15:59:55.0	57.50	137.00	25	7.1	15:59:51.8	57.67	136.80		6.7
21 6 1928	16:27:13.0	60.00	146.50	25	7.0	16:27:14.9	60.21	147.09		6.6
07 3 1929	01:34:39.0	51.00	170.00	50	8.6	01:34:39.3	50.66	169.69		7.6
26 5 1929	22:39:54.0	51.00	131.00	0	7.0	22:40:03.0	50.76	130.80		
27 4 1933	02:36:04.0	61.25	150.75	25	7.0	02:36:05.3	61.04	151.10		
04 5 1934	04:36:07.0	61.25	147.50	80	7.2	04:36:05.4	61.40	147.74		6.5
22 7 1937	17:09:29.0	64.75	146.75	25	7.3	17:09:30.7	64.52	146.77		6.9
10 11 1938	20:18:43.0	55.50	158.00	25	8.7	20:18:40.1	55.35	158.38		8.2
22 8 1940	03:27:18.0	53.00	165.50	25	7.1	03:27:13.6	52.17	165.36		6.8
09 9 1942	01:25:26.0	53.00	164.50	80	7.0	01:25:22.5	52.95	166.19		5.8
03 11 1943	14:32:17.0	61.75	151.00	25	7.3	14:32:18.4	61.75	150.88		7.0
27 7 1944	00:04:23.0	54.00	165.50	70	7.1	00:04:25.2	54.05	165.47	22.9	
12 1 1946	20:25:37.0	59.25	147.25	50	7.2	20:25:38.2	58.95	147.25		6.2
01 4 1946	12:28:54.0	52.75	163.50	50	7.4	12:29:01.5	52.94	163.20		
16 10 1947	02:09:47.0	64.50	147.50	50	7.0	02:09:46.6	64.01	147.50		7.0
14 5 1948	22:31:43.0	54.50	161.00	25	7.5	22:31:43.4	54.55	161.00		7.5
22 8 1949	01:01:11.0	53.75	133.25	25	8.1	01:01:14.2	53.56	133.28		
27 9 1949	15:30:45.0	59.75	149.00	50	7.0	15:30:44.9	60.03	149.11		6.6
13 2 1951	22:12:57.0	56.00	156.00	0	7.0	22:12:55.6	55.57	156.29	2.7	7.0
02 1 1957	03:48:44.0	53.00	168.00	0	7.0	03:48:43.4	52.68	167.98		
09 3 1957	20:39:16.0	52.30	169.00	0	7.1	20:39:17.8	52.45	169.57		
22 3 1957	14:21:10.0	53.74	165.66	20	7.0	14:21:11.0	53.58	165.81	10.1	
10 4 1957	11:30:00.0	55.96	153.86	0	7.1	11:29:59.5	55.82	153.86	3.5	
19 4 1957	22:19:26.0	52.00	166.50	0	7.3	22:19:29.3	52.01	166.37	4.6	
07 4 1958	15:30:40.0	66.03	156.59	0	7.3	15:30:41.3	65.82	156.41	3.1	7.0
10 7 1958	06:15:51.0	58.60	137.10	0	7.9	06:15:57.2	58.13	136.35	7.7	7.8
13 11 1960	09:20:32.3	51.40	168.80	32	7.0	09:20:33.6	51.10	168.75	7.7	

Table 2: Estimates of Seismic Moments Obtained in This Study

Date	Estimate	
	Mantle magnitude M_m	Seismic Moment (10^{27} dyn-cm)
07 3 1929	8.0	10
10 11 1938	8.7	46
22 8 1949	8.4	23
10 7 1958	7.8	6