EARTHQUAKE NOTES

EASTERN SECTION
SEISMOLOGICAL SOCIETY OF AMERICA

R. R. Bodle, Editor
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IN MEMORIAM

Reverend Francis Anthony Tondorf, S. J.

In the death of Father Tondorf, November 29, 1929, seismology in the United States suffered a great loss. It was probably due to his persistent efforts to popularize seismology and to his success in enlisting the cooperation of the various press agencies more than to any other single cause that the interest of the general public in the eastern states was gained and held for seismology. His name became a household word and with it the subject of earthquakes. He was very active in fostering the cooperative program of earthquake investigation with the U. S. Coast and Geodetic Survey and Science Service.

Father Tondorf was born in Boston, Massachusetts, July 17, 1870, and his boyhood was spent in his native city. After attending Boston College for some time, he entered the Society of Jesus, August 14, 1888. As a Jesuit he studied in Woodstock College and at Saint Louis, Johns Hopkins, and Georgetown Universities. He was ordained to the Catholic priesthood at Woodstock and received his doctorate at Georgetown.

Father Tondorf was assistant in the Astronomical Observatory at Georgetown for some years prior to the opening of the Seismological Observatory in 1911. From the beginning he aimed at a first class station but was hampered by lack of means. In 1911 he installed a horizontal component and a vertical component Wiechert seismograph, each of eighty kilograms mass, in the south tower of the Administration Building, and two horizontal components of the Bosch-Omori type in a separate building near the Astronomical Observatory.

However, these were soon replaced by a photographic Bosch, a two hundred kilogram Wiechert, a Mainka, and finally a vertical component Galitzin of the Cambridge type in a specially constructed cave under the quadrangle. Father Tondorf's last addition to the equipment of the station was a pair of horizontal component, Galitzin seismographs of the Cambridge type.

Although always an invalid he accomplished much because of his extraordinary gifts and his indomitable will. His interests were many and his talents as varied. His scientific work is known to all. But his literary gifts were surprising. His English style was strong and facile. And his Jesuit companions always marvelled at his dexterity in writing Latin verse. Whenever a Latin document or inscription was to be composed, Father Tondorf was always in demand. He will be missed by all but most by his Jesuit brethren who had the best opportunity to know him.

James B. Macelwane S.J.

Seismologists are generally interested in the successor to Father Tondorf. Father Frederick Wyatt Sohon, S.J., of Georgetown University has been selected. While his recent work has been in astronomy he was in charge of the Fordham Seismological Station in 1923 and 1924 during the period of installation of the Milne Shaw instruments and in addition made studies in seismology with the assistance of Father Lynch, now in charge of the Fordham Station and vice-chairman of the Eastern Section.

PRELIMINARY REPORT OF THE SUBMARINE EARTHQUAKE OF NOVEMBER 18, 1929.

A report of this earthquake will be prepared by the Dominion Observatory, Ottawa, Canada. The present preliminary report is based on material furnished by the Dominion Observatory, Nature of London, the U.S. Coast & Geodetic Survey, cable companies, numerous seismological observatories, a large number of individual reports on the visible and felt effects of the earthquake, and press reports.

Mr. C. Davison, an authority on seismology, has the following to say in NATURE.

A remarkable effect of the earthquake was the fracture of a large number of telegraph cables. Of the twenty-two cables that traverse the central district, twelve were damaged, and ten of these cross the Atlantic. The probable site of the breakages is said to be in Lat. 44° N., Long. 57° W. The fractures, however, were not concentrated in one spot, for two of the Western Union cables were severed at a depth of 90 fathoms off the coast of Nova Scotia, while a third, belonging to the same company, broke at a depth of 900 fathoms. The exact positions of the fractures will throw light on the origin of the earthquake. It may be that all twelve sites will be found to lie along a straight line, as happened in 1884 with three cables on the south-eastern slope of the Newfoundland Bank. At the same time, it seems quite possible that the earthquake may have had a multiple origin and that a displacement not far from land was responsible for the strong shock felt in Nova Scotia. It is difficult otherwise to account for the damage at Windsor, slight as it was, this town being more than 300 miles from the spot assigned to the fractures. On the other hand, that the sea-waves originated at a distance from land of this order of magnitude seems to be indicated by the long interval that elapsed between the earthquake and the arrival of the waves.

That the disturbed area was one of great size is clear from the length of coast shaken. As Boston is 700 miles from the spot above mentioned, it is possible that the disturbed area may have contained so much as 1-1/2 million square miles, an area that has seldom been exceeded in earthquakes of the last fifty years.

DOMINION OBSERVATORY, OTTAWA, HAS SENT OUT THE FOLLOWING PRELIMINARY NOTES ON THE GRAND BANKS EARTHQUAKE OF NOVEMBER 18, 1929.

A severe earthquake was registered on most of the seismographs of the world on the afternoon of Monday, November 18th, 1929. The preliminary location, as determined from earthquake records, is placed by the Dominion Observatory, Ottawa, as at 44° 30' north Latitude 57° 15' west Longitude. The time at the epicentre was 3 hours, 32 minutes, and 8 seconds, P.M., Eastern Standard Time.

The earthquake was felt over a very wide area. Quite a number of persons in Ottawa felt the tremors with sufficient definition to cause them to telephone the Observatory to ask if an earthquake were in progress. Tide gauge records along the Atlantic coast showed slight traces of tidal wave, seldom exceeding a couple of feet. The records were somewhat conflicting due to the fact that there was a strong off-shore gale blowing at the time. The tide rose as much as eight feet off the coast of Cape Breton, but no damage was done. The newspaper report of a shifting of a bridge at Grand Narrows has been found to be in error.

A tidal wave, which caused considerable damage and loss of life, was propagated northward from the epicentre, and reached its greatest height in Placentia Bay, Nfd. The west side of the Bay sustained the greatest loss of life, owing to the comparatively narrow channel off Burin Harbour, which seemed to concentrate the rising water and intensify its action at that point. Although Sable Island lay less than a hundred miles from the epicentre, only about a third of the distance from the epicentre to Placentia Bay, and although the Island is very low-lying and might be expected to suffer heavily in case of a tidal wave, no such wave was experienced there. The explanation for this has not yet been very satisfactorily established.

Ten of twenty-one cables crossing the disturbed area were severed. Nearly all were broken at more than one point. The breaks occurred at points far south of the region which is designated as the epicentre by the seismogram readings. Some breaks did not occur at the time of the earthquake, but somewhat later, which would lend strength to the assumption that some of the breaks were caused by submarine landslides.

A thorough study of all available data is being made at the Dominion Observatory, Ottawa, Canada. Requests have been sent out to all the seismograph stations of the world at which records might be presumed to have been registered. A wide distribution of questionnaire forms to postmasters and editors has been made. The cooperation of the Department of Marine and Fisheries has been secured, permitting a study of tide gauge records, and the cooperation of cable companies and other organizations in a position to furnish information has been sought. The cooperation of the United States Coast and Geodetic Survey has been promised.

It will take some time to assemble and still longer to make a thorough study of all the data which are being collected. Further information may cause some modification in the exact position of the epicentre, though it is believed that the modification will largely take the form of a definition of the epicentre as a long "fault" or break or as a sunken area. The time as determined is probably correct to the nearest second.

Dominion Observatory,
Ottawa, Canada.
December 6, 1929.

PRELIMINARY INFORMATION FROM THE U. S. COAST AND GEODETIC SURVEY IS AS FOLLOWS:

Though it is not a complete list of the stations where the earthquake was recorded the following, whose reports were received (mostly through Science Service) in the office of the U. S. Coast & Geodetic Survey within a short time, give a general idea of the great force of the shock: Fordham University; the Dominion Observatory at Ottawa, Canada; St. Louis University; West Bromwich, England; Georgetown University; Manila, P. I.; Ann Arbor, Mich.; Victoria, B.C.; Berkeley, Calif.; Cambridge, Mass.; Charlottesville, Va.; and the following Coast & Geodetic Survey stations; Tucson, Ariz.; Honolulu, Hawaii; Sitka, Alaska.

Seismic sea-wave effects were recorded on tide gauges of the U. S. Coast & Geodetic Survey. The most pronounced effect being noted at Ocean City, Md., where a change of approximately nine tenths of a foot was noted. The following figures are based on the assumption that the epicenter was 44 degrees 30 minutes north latitude and 57 degrees 15 minutes west longitude.

	Times of arrival	Elapsed time	Distance traveled	Approximate rate of travel
Atlantic City	7 h 50 m p.m.	4.3 hr	1026 mi	239 miles/hr
Ocean City, Md.	7 h 20 m p.m.	3.8 hr	1087 mi	286 miles/hr
Charleston, S.C.	9 h 24 m p.m.	5.86 hr	1504 mi	257 miles/hr

Attention is called to the fact that the times of arrival were not dependent upon the distance from the epicenter. The progress of the wave seems to have been retarded depending on its course. A direct line to Atlantic City passes inside the 100 fathom line nearly all the way. A line to Ocean City, Md., is to some extent outside the one hundred fathom line while a line to Charleston, S.C., passes over an average depth of one thousand fathoms until the region of Cape Hatteras is reached. Shoal water is encountered south of Cape Hatteras.

At the time of the earthquake a severe storm was raging along the New England coast and tidal effects were undoubtedly difficult to ascertain. No fluctuation was shown on the gauge at Boston, Mass., but press and other reports give tidal disturbances at Bar Harbor, Belfast, near Cherryfield and at Portland, Me. Very high waves (20 to 30 feet), probably storm waves, were reported at Portland. High tides were reported near Exeter, N. H., Barnstable, Mass., and Block Island. Fishermen near Block Island reported cross seas to the prevailing swell which they could not account for. Undoubtedly some of these effects upon the rise and fall of the tide were due to seismic sea waves.

CHARACTER OF SHOCK AS DEFINED BY FELT REPORTS. Out of 167 reports received from New England and New York State 70 reported the earthquake not observed, principally in New York, Conn., and Vermont. From a compilation of the reports the following characteristics were deducted; the earthquake consisted of one shock which began gradually with a trembling motion or described as a swaying motion by about half the reports received from the state of Massachusetts. Of those reporting the

direction of the ground motion, 55% reported it to be N-S and 30% reported it to be E-W. A moderately loud rattling or thunderous noise at the time of the shock was observed.

ANALYSIS OF ISOSEISMAL MAP. This map, constructed from, earthquake reports, press reports and personal letters received, defines two areas of intensity 5 within United States territory, on the coast of Maine. Quite remarkable are the two areas at Cape Ann and Narraganset Bay where the shock was not felt. The intensity observed in the Connecticut River valley was slightly greater than the ajoining areas. Isoseismic line of intensity 3 follows the Green Mountain and the Berkshire ranges to Long Island Sound, indicating that these mountain ranges tend to halt further propagation of the disturbance. The shock was felt in Burlington, Vt. force 4 on made ground only, also in New York City probably due to the large area of made land.

An area of such geological formation as to render it more susceptible to the propagation of seismic disturbances as compared with the surrounding areas, extends from a point between the Catskill and Adirondack Mountains in a southwesterly direction towards Binghampton, N.Y. This area was also disturbed by the earthquake of August 12, 1929.

SOURCES OF INFORMATION. The isoseismal map is based on information from (1) Earthquake Questionnaires which were mailed principally to Postmasters throughout New England and New York (2) from letters received from interested people and (3) press reports.

(1) 167 questionnaire reports were returned from postmasters, weather observers, and others.

(2) 26 personal letters were received. These were principally instigated by press statements that reports were desired.
(These notices were requested through Science Service, Washington,D.C.)

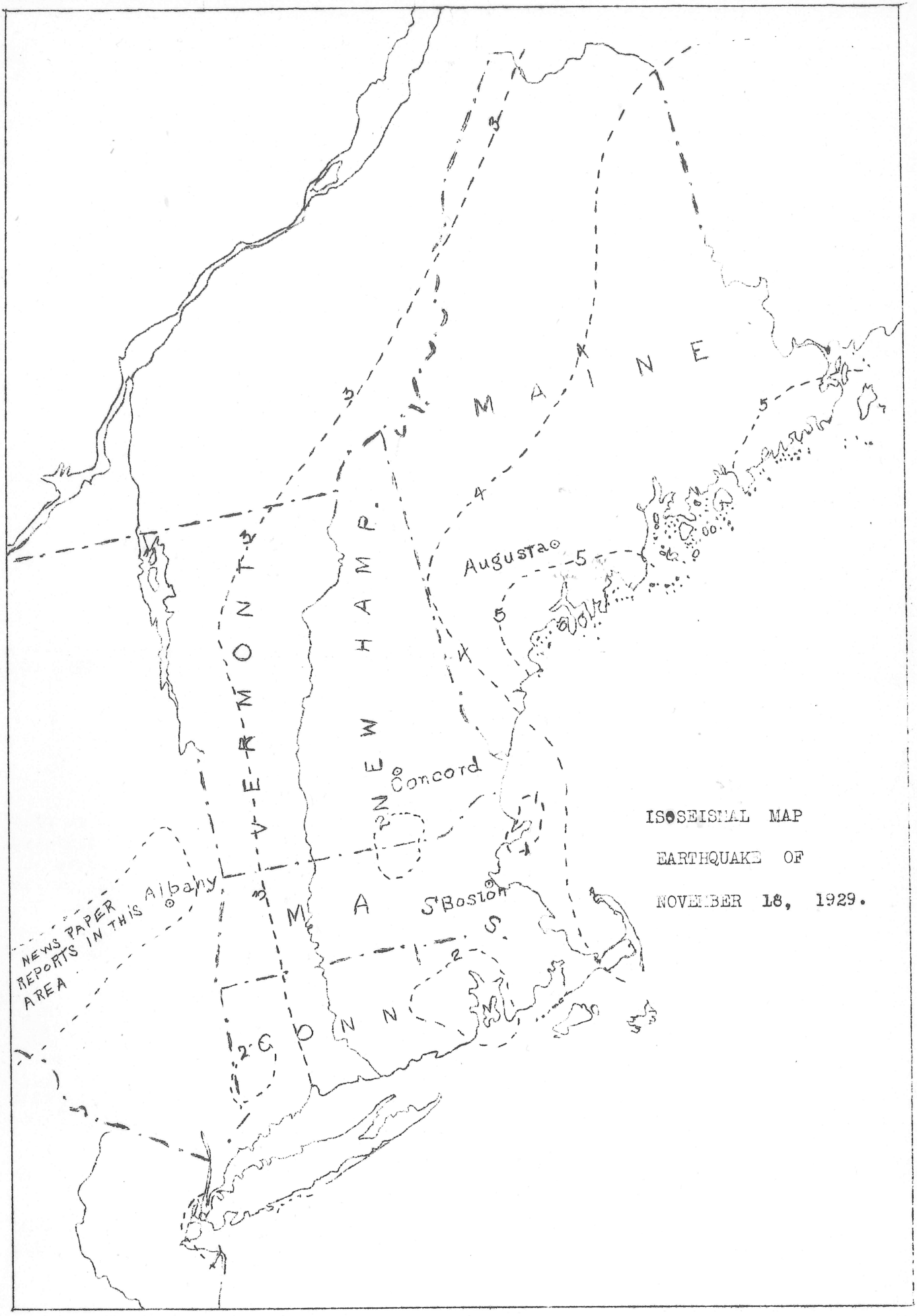
(3) The numerous press reports were used to some extent in the construction of the isoseismal chart.

DAMAGE AND REMARKABLE EFFECTS IN THE UNITED STATES. The earthquake was felt as far west as central New York state but very faintly there. The region of greatest severity (force 4-5) within the United States was the southeast half of the state of Maine bounded by a NE and SW line through the center of the state. Within this area clocks stopped, articles were shaken from shelves in many places and people moderately alarmed, rushing from buildings in a few instances. No damage was done. A bridge between Portland and South Portland, Maine, swayed considerably but was not displaced or damaged.

REPORTS FROM SHIPS. Reports have been received which state that ships within 50 to 300 miles of the epicenter were shaken severely, producing an effect similar to hitting submerged objects or thowing a propeller blade. The sea was distinctly disturbed and became choppy. These reports have led to an estimation that at the epicenter the earthquake was of force 8-10 in intensity. It seems certain that had this shock occurred in an inhabited region great destruction would have resulted.

EARTHQUAKE IN OKLAHOMA

Newspapers recently carried items concerning an earthquake in the region of Oklahoma City and westward. The time as reported was about 6:30 a.m., Central Time, December 27, 1929. No damage was done beyond alarm to the population in


MAINE
NEW HAMP.
VERMONT
MASS.
CONN.
Augusta
Concord
Albany
Boston
NEWS PAPER REPORTS IN THIS AREA
ISOSEISMAL MAP
EARTHQUAKE OF
NOVEMBER 18, 1929.

some regions where they ran from their homes. Since that time a number of reports have been received which indicate that the shock was felt as far north as Enid in Garfield County and as far west as Moorewood in Custer County. Though at first a comparatively small area (possibly 900 square miles) was thought to have been shaken, it is now estimated that some 3,000 square miles or more were included in the disturbed area. The larger part of this area extends along the course of the Canadian river and includes nearly all of Canadian County on the east and approximately two thirds of Custer County to the westward. A narrow strip of territory where the shock was felt runs north from the main area to Enid in Garfield County and includes the western half of Kingfisher County. It is reported that another shock was felt in the same region some twelve or fifteen years ago.

A rather sharp earthquake was reported to have been felt in the region of Charlottesville, Va., at 9:56 p.m., Eastern Standard Time, December 25. The shock was recorded on the seismograph at the Rouse Physical Laboratory which is at the University of Virginia. Mr. Arthur J. Weed,who is in charge there, estimated the shock to have originated somewhere within a radius of 100 miles of that station.

THE FOLLOWING ITEMS APPEARING IN NATURE (LONDON) OCTOBER 19, 1929 ARE OF INTEREST TO SEISMOLOGISTS.

MEXICAN EARTHQUAKE SEA-WAVES OF JUNE 16, 1928.

During the afternoon of June 16, 1928, a strong earthquake occurred off the coast of Mexico. The epicenter was in the Acapulco Deep, about 125 miles south of the Mexican state of Oaxaca. Though the origin was so distant, coast towns in this region suffered considerable damage. The sea-waves that swept over the shores and added to the destruction were recorded at Hilo (Hawaiian Volcano Observatory Monthly Bulletin for June 1928). The waves reached the station on June 17, 8 hr. 29 min. after the occurrence of the earthquake, the maximum range of movement being about 16 inches, and the period at first about 22 minutes, or approximately the same as the period of the natural water oscillation of Hilo Bay. The distance of the origin from Hilo being 3860 miles, it follows that the mean velocity of the sea-waves was 455 miles per hour, a figure that agrees closely with the values obtained for other sea-waves across the Pacific, namely, 453 miles per hour for the Japanese earthquake of 1896 and 465 miles per hour for the Valparaiso earthquake of 1906.

EARTH-TILTING BY TIDAL LOADING

A valuable contribution to our knowledge of the tilting of the earth's crust caused by tidal loading has lately been made by Mr. R. Takahasi (Earthq. Res. Inst. Bull., Vol.6, pp. 85-108, and Vol. 7, pp. 95-101; 1929). Two of Prof. Ishimoto's tiltmeters, constructed entirely of silica, were placed on a concrete platform on the floor of a cave cut in Mesozoic rock at Misaki near the southern

end of the Miura peninsula, Sagami Bay. The cave is covered with a thick growth of weeds and a forest of pine yrees, and is so effectively shaded from solar radiation that variations of temperature in the cave are too small to be recorded by the ordinary thermograph. The instrument is 28 feet above mean sea-level, 25 yards from the nearest beach-line, and less than a quarter of a mile from the tide-gauge station of Aburatubo Bay. Mr. Takahasi shows that the tilting of the crust follows quite faithfully the ebb and flow of the ocean tides, a rise of 13 inches in the sea-level at Aburatubo producing a tilt of 0.22" at Misaki. The observed tilting is almost entirely the effect of tidal loading, other causes leading to a deflection of less than 0.01". In the Bay of Aburatubo, remarkable seiches with a period of 15 minutes are sometimes observed, and the record of the tiltmeter is then serrated by minute indentations with a mean period of 15 minutes. The seiches were recorded at different points of the Bay, and it was found that the tiltmeter record follows the curve of seiches obtained at a point 25 yards from the station, but not one at a point 160 yards distant. In other words, the load that is really effective in promoting tilting is that applied at a distance less than 160 yards.

EPICENTERS

Since the last issue of EARTHQUAKE NOTES the following epicenters have been determined. Through cooperation of Science Service data are exchanged between the Coast and Geodetic Survey and the Central Office of the Jesuit Seismological Association. The following are means of the two determinations when both are available. Organizations making the determinations are indicated by initials. - St. Louis University STL, Coast Survey CS.

Date 1929	Time h	m (Greenwich)	Latitude	Longitude	Remarks
October 5	7	00.1	55 N	160 E	STL
6	7	52.2	19 N	155 W	STL, CS.
19	10	13.0	20.5 S	72.5 W	CS
November 15	18	50.7	8 N	143 E	CS
17	3	43.2	11 N	123.5 E	CS
18	20	32.1	44.5 N	57.2 W	Dominion Obsy. Ottawa
December 17	10	58.7	53.5 N	171 E	CS

ABSTRACTS OF PAPERS AT THE NEW YORK MEETING

In the issue of Earthquake Notes dated October 25 the name of the author was in error for the paper abstracted on the bottom of page seven. The paper deals with surface waves and, though Dr. Gutenberg is indicated as the author, it was prepared by Dr. Macelwane.

THE PRINCIPLES OF SEISMIC PROSPECTING

By L. Don Leet

(Presented at the last meeting of the Eastern Section of the Seismological Society of America.)

The term "Seismic Prospecting" is usually applied to the study of subsurface geologic structure by means of elastic waves set up by dynamite blasts and recorded on tromometers, following the general theory of seismology. The greater part of such work, however, has had for its more limited objective the location of salt domes as favorable structures for the accumulation of oil.

The discussion presented, where it involves field procedure, is confined to this type of prospecting, with special emphasis on one of its most recent developments--work over water-covered areas. The purpose is to consider general principles.

The subject is introduced by a history of the problem, followed by the geological history of the gulf coastal plain; the problem of locating salt domes; the introduction of seismic methods; a discussion of the theoretical basis for seismic prospecting, of field methods, and of results and costs.

Accepting salt dome prospecting as a closed field, for the moment, certain features are discussed pertaining to the possibilities of the seismic method for the exploration of subsurface conditions which might lead to quantitative data on other structures than salt domes. Six points are mentioned. Some or all of them may have been met by companies in the field, but if they have, a veil of secrecy cloaks the results.

In conclusion, consideration is given to the possible sources from which aid may come for the future development of the theory of the method. Whatever the means ultimately made available, the matter should engage the interest of all seismologists, if for no other purpose than the protection of the science's good name. There are many things being done in its name for which seismology should be none too eager to claim or admit responsibility.

ISOSTASY AND EARTHQUAKES

By William Bowie
Chief, Division of Geodesy, U. S. Coast and Geodetic Survey.

(Presented at the last meeting of the Eastern Section of the Seismological Society of America.)

Isostasy is a condition existing in the outer part of the earth, now accepted as a scientific principle. The proof of isostasy has resulted from analyses of geodetic data. The proof of isostasy leads to some definite knowledge as to the outer portion of the earth called the crust and this, necessarily, has an influence on the science of seismology. The material of the outer 60 miles of the earth has residual rigidy, otherwise the irregular configuration of the earth's surface could not be maintained for long geological periods. The material below this 60 mile depth must be plastic in order that the isostatic condition may be maintained. These conditions would indicate that the epicenters of the earthquakes lie above the 60-mile depth. The determination of gravity at sea by Dr. Vening Meinesz of the Dutch Geodetic Commission, aboard submarines, adds to geophysical data for ocean areas and analysis of his gravity data indicates that isostasy is true for the crust under the oceans to a degree comparable with that for the crust under continents. This is a matterof importance in seismology since many great earthquakes occur under ocean areas.

ATTENTION is called to the following articles in the Scientific American for November, 1929.

Amateur Seismology, Page 411.
Power from the earth, Page 422.
Also, a paper by Dr. Brown on page 426 dealing with the apparent variation in the rotation of the earth.

The Coast & Geodetic Survey maintains a mailing list (No.109K) by means of which persons desiring such information may be notified whenever a publication on the subject of seismology is issued by the Bureau. No charge is made for this service. The publications are later listed in the bibliography of seismology but time may be saved by the plan described.

PERSONAL NOTES

John R. Freeman recently returned from attending the World Engineering Congress at Tokio, Japan. While there he gave considerable attention to the engineering problems in connection with earthquakes. He purchased a tiltmeter and is considering its installation at a suitable place.

Dr. J. B. Macelwane, Director of the seismograph station at the University of Saint Louis, will spend the summer semester in Europe. He plans to work chiefly with Karl Uller on the general theory of elastic waves. Karl Uller is a member of the faculty at Hessische Ludwigs-Universität at Giessen, Germany. In August, Dr. Macelwane plans to attend the meeting of the International Union of Geodesy and Geophysics at Stockholm.

N. H. Heck recently returned from an extended trip to the Pacific Coast going by northern routes and returning by the southern and visiting a number of places en route where seismological work is being done or is in prospect. At Bozeman, Montana, there is considerable interest in a cooperative seismological station in the region of the Montana earthquake of 1925. Improved conditions of operation and utilization of records were discussed at the University of Washington at Seattle. At San Francisco, Berkeley and Stanford attention was given to collection of information in the Pacific Coast region and especially to ascertaining views as to the future trend of work in all fields of seismology. In addition to the programs of investigation of local earthquakes in Southern California and the Bay region, teleseismic stations of the first rank are now functioning or nearly ready to function at the University of California, University of Santa Clara and at the Research Laboratory at Pasadena. These stations are going to help greatly in the location of earthquakes. The shaking platform at Stanford University is continuing to produce valuable results. There is every indication that work of great importance in almost every field of seismology is going forward in California. At a meeting of the committee of the Society on an earthquake catalogue for California plans were worked out for completing the catalogue. At Pasadena the outstanding feature is the steady collection of information regarding earthquakes heretofore considered too small to be noted but which may prove to be of very great importance. The Wood Anderson seismometer has now reached a very high state of efficiency and seems to be a remarkable instrument for the recording of nearby earthquakes.

One of the problems in the collection of earthquake information is to find the right person to make the reports. Reports that are received in response to questionnaires are of generally high caliber but it is obvious that it is not easy to answer some of the questions and education and training is of assistance. In this connection Prof. Harold E. Culver of Pullman, Washington, State Geologist of Washington, has made the interesting suggestion that there are throughout the western mountain region many men who with college education prefer to live in the smaller places and that these men would in nearly every case be ready to cooperate. This suggestion is of considerable interest.

Following a suggestion by Neumann test records with two Wenner horizontal seismographs running side by side were recently made by Mr. H. E. McComb. The instruments were both recording motion for the same component and produced records that were identical. This would indicate that the instruments were very efficient

especially when their large magnification is considered.

E. R. Hand in charge of the San Juan, P. R., observatory of the U. S. Coast & Geodetic Survey reports that the new office building has been completed. A modern seismograph to replace the one put out of commission by the hurricane of 1928 will soon be installed and observations resumed. Had this station been operating during the recent Newfoundland earthquake it would have furnished some very valuable information.

EASTERN SECTION MEETING

The next meeting of the Eastern Section of the Seismological Society of America will be a joint meeting with the Section of Seismology of the American Geophysical Union. The meeting will take place on Monday and Tuesday, May 5th and 6th of the week following the meeting of the National Academy of Sciences and of the American Geophysical Union.
