Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SSS024-01 Room:301A Time:May 27 09:15-09:30

The chain reaction tendency of a deep-focus earthquake and the shallow-focus earthquake

Fusashi Hiramichi[1*]

[1]Hiramichi equipment design

Process

I noticed that a deep-focus earthquake occurred frequently just before 2,003.7.26 Miyagi offing .9.26 tokachi offings Earthquake during around 4th. I began investigation about connection with a deep-focus earthquake and the shallow-focus earthquake. Even the Shizuoka offing discovered that there was a similar tendency deep-focus earthquake frequent occurrence with circumference in Ibaraki offing, 2009 in Chishima Islands earthquake, 2008 in Chuetsu Earthquake and November, 2006 in 2004 while I continued investigating it.

A hypothesis

A plate tends to creep in to a deep-focus earthquake to occur on a line and the following a shallow-focus earthquake in a chain reaction

1. There may be the area that is easy to be affected by the nidus of the deep-focus earthquake in particular
2. In addition, how about the diving underwater position of the plate that the deep-focus earthquake occurs and 1. relations?
3. Is not there a constant correlation by above 1.2.

Inspection

1. About having outbreak local deflection or not of the shallow-focus earthquake corresponding to the deep-focus earthquake nidus
2. About an earthquake and 1. relations that happened in the area where it seemed that the plate that the deep-focus earthquake occurred crept in
3. About the area that was able to confirm by above 2. about having correlation or not

5. An inspection method

1. I extracted a plate border earthquake at a latitude and longitude / depth and demanded the incidence of the shallow-focus earthquake that a plate crept in within five days, and occurred on a line from there. A formula 1.
2. I extract all shallow-focus earthquakes of the condition a period / a latitude and longitude / depth same as the above and find an average incidence. A formula 2.
3. I compare 2. with above 1.

A formula

A. It is number of the shallow-focus earthquakes / of shallow-focus earthquake average incidence outbreak time several a day = of five days after deep-focus earthquake outbreak*5 days

B. The shallow-focus earthquake incidence number of the total shallow-focus earthquakes/of the outbreak several a day = same range of the time of peace Total man_days)

Comparison magnification = A/B

Keywords: deep-focus earthquake

Japan Geoscience Union Meeting 2011
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SSS024-02 Room:301A Time:May 27 09:30-09:45

The variation recorded by waveform images of the F-net at the 2007 Niigataken Chuetsu-oki EQ - 1: Daily plot

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1. Preface

The F-net Broadband Seismograph Network, which is composed of around 100 STS-1 and -2 seismometers, is the network for monitoring earthquakes. Their records are open to the public through its homepage(1).

The homepage provides waveform images (daily plot) in addition to digital data of the waveforms. The purpose of the waveform images could be to help determination of period for waveform data, but they can also be data of seismicity. Because the daily plot is a GIF format image, and whose size (unit: KB, Kilo byte) relates to total length of the drawn lines, further relates to total amount of vibration of the ground where the seismometer is installed. The mathematical explanation of the so far mentioned is shown below, where the symbol => shall mean existence of relationship between the two in this document.

Size of F-net waveform image (KB, Kilo byte)
=> Total length of the drawn lines
=> Total amount of vibration of the ground

The size of the image is summation of drawn lines for specified period, thus it is different from waveform, which is an instant value. The elements which affect its size are amplitude (velocity), frequency and duration of vibration, and it seems that amplitude and duration of vibration affect the value very much.

2. Analyses

2.1 There are several analyses already conducted(2),(3).

2.2 2007 Niigataken Chuetsu-oki Earthquake

<Method>

Total of 10 stations surrounding Kashiwazaki, where is the place of the epicenter, are investigated for the period from May 1, 2007 to July 31, 2007. Directions of the investigated vibrations are East-West and Up-Down.

<Results>

* The all measurements show variation during the period in a similar way.
* Among them, only Kasiwazaki station (Code KZK) shows very large fluctuation for short periods. Those periods are each several days around 50 and 30 days before the EQ. The latter could be of earth tides' effect.
* The author investigated if weather and sea conditions as well as human activities affected the measurements, but there were no significant such effects to the measurements, thus it can be concluded that the observed variations are results of tectonic activities near epicenter of the EQ.

Gratitude

The author thanks to National Research Institute for Earth Science and Disaster Prevention (NIED) for the use of F-net data.

References

(1) F-net home page, http://www.fnet.bosai.go.jp/top.php?LANG=en.
(2) Yoshiki Sue, 2010, Long-period vibration recorded by waveform images of the F-net Broadband Seismograph Network, Part 1(In Japanese), SSJ Fall meeting abstract D31-12.
(3) Yoshiki Sue, 2010, Long-period vibration recorded by waveform images of the F-net Broadband Seismograph Network, Part 2(In Japanese), SSJ Fall meeting abstract P3-60.

Keywords: earthquake, F-net, earth tides, Niigataken Chuetsu-oki

Japan Geoscience Union Meeting 2011
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SSS024-03 Room:301A Time:May 27 09:45-10:00

Earthquake forecast testing experiment in Japan: Overview and test results

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We joined the Collaboratory for the Study of Earthquake Predictability (CSEP) and installed, through an international collaboration, the CSEP Testing Center in Japan as a part of the Japanese earthquake prediction research program (2009-2013). We have started to conduct a verifiable prospective testing experiment since November 2009. Its major feature of the experiment consists of using Japan, one of the most seismically active and well-instrumented regions in the world, as a natural laboratory. To make full use of this location, we have set up the infrastructure and rules for this Japanese experiment by slightly modifying the original CSEP. The experiment consists of 12 categories, with 4 testing classes with different time spans (1 day, 3 months, 1 year and 3 years) and 3 testing regions called "All Japan," "Mainland," and "Kanto." A total of 91 models were submitted, and are currently under the CSEP official suite of tests for evaluating the performance of forecasts. Demonstrating example test results is a key element to illustrate possible scenarios of the experiment. In this presentation, we present an overview of the experiment and several results obtained for the "All Japan" and "Mainland" regions. We argue that the results are just the first of its kind and more trials under the same controlled environment need to be attempted to understand the universal feature of each model and to look for the intrinsic predictability of earthquake rupture process. This turns out to be one of the gold standards of the CSEP mission.

The details of the results are given at http://cseptesting.eri.u-tokyo.ac.jp/results/. See also the special issue of the Earth, Planets and Space "Earthquake Forecast Testing Experiment for Japan," hopefully published in March 2011.

Keywords: Earthquake dynamics, Global collaboration, Computational seismology, Earthquake interaction, forecasting, and prediction, Mathematical and computer modeling, Statistical analysis

Japan Geoscience Union Meeting 2011
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SSS024-04 Room:301A Time:May 27 10:00-10:15

The improvement of the model testing for the earthquake forecasting models

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[1]National Institute of Polar Research, [2]Earthquake Research Institute

When there are some earthquake forecasting models, we need to evaluate them. For the evaluation methods, L-, N-, M-, S- and R-tests based on the Poisson distribution are often used in the Coordinating Committee for Earthquake Prediction (CCEP). However, there are several problems for the L-test. For example, the score on the L-test is often better even if the score on the N-test and S-test are very bad. It may be caused by the shape of the likelihood of the Poisson distribution. The mode of a Poisson distribution with the expectation is the maximum integer not greater than the expectation. Therefore, the difference of the sum of expectations and the sum of observations become large in the L-test that verifies many regions at same time.

So, we show the problem of L-test by the numerical simulation and suggest some improvement methods.

Keywords: earthquake, forecasting model, test

Japan Geoscience Union Meeting 2011
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SSS024-05 Room:301A Time:May 27 10:15-10:30

Understanding of crustal activity based on spatiotemporal relationships between various geophysical measures (4)

Masashi Kawamura[1*], Takeshi Kudo[2], Koshun Yamaoka[3]

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For comprehensive understanding of crustal activities, which are expected to be accompanied by their time variations prior to large inland earthquakes, it is important to develop a monitoring index / indices which are useful for monitoring of crustal activities. With the aim of developing monitoring indices well featuring crustal activities, we have focused on the spatiotemporal relationships between any two of geophysical measures, at least one of which must be time-variable. For smooth comparisons between geophysical measures, we have created a database with spatially and temporally gridded formats from geophysical datasets such as seismicity, GPS, gravity anomaly, and geothermal gradient, which reflect crustal activities with different time scales. As a further step to create a monitoring index / indices, we developed a statistical validation system which evaluates the association of the relationship between geophysical measures with the occurrence times of large inland earthquakes. Furthermore, we have improved the system by adding a statistical evaluation process based on error diagram (Molchan diagram). This leads to more improved and informative statistical evaluation than the previous one, which was based on only probability gains of true positive ratio (prediction rate) and hit rate (alarm rate) calculated from a contingency table. The improved validation system requires the input of a pair of geophysical measures, various adjusted parameters such as a grid interval of gridded data used, and definition of a monitoring index, and leads to the output of the result of the statistical evaluation based on probability gains of true positive ratio and hit rate and error diagram. We applied the improved system to four pairs of seismic and geodetic measures (seismic energy, the number of earthquakes, dilatation rate, and maximum shear strain rate) over inland Japan with designated spatially and temporally gridded data formats, which were obtained from the JMA hypocenter catalog and the GSI GEONET data, respectively. In this application, we defined the same monitoring indices for the four pairs as in Kawamura *et al.* (2010). With the improved system, the monitoring index created based on the relationship between dilatation rate and seismic energy turned out to statistically most reflect the temporal changes in crustal activities prior to large ($M >= 6.0$) inland mainshocks. This was consistent with the result based on only probability gains of true positive ratio and hit rate in Kawamura *et al.* (2010). This result needs to be validated by updating the database to which the improved validation system is further applied.

Keywords: Seismicity, Strain rate, Spatiotemporal relationship, Crustal activity, Probability gain, Error diagram

Japan Geoscience Union Meeting 2011
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SSS024-06 Room:301A Time:May 27 10:45-11:00

Identification of Predictive Foreshock Activity by Statistical Method along the Japan Trench

Kenji Maeda[1*], Fuyuki Hirose[1]

[1]Meteorological Research Institute

Foreshocks have been thought one of the most promising phenomena to predict large earthquakes. However, foreshocks are mostly found after a large earthquake occurred and it is very difficult to distinguish them deterministically from background seismicity before a mainshock occurs. Therefore, probabilistic approach is realistic way to use foreshock activity as a precursor of a mainshock. So, we investigate probabilistic features of foreshocks and search for effective parameters to define foreshocks which present relatively high performance to predict large earthquakes. Maeda (1996) once proposed a foreshock definition which gives relatively high performance to predict large earthquakes. We basically apply the same method as Maeda (1996) to the data from 1980 to 1993 using the new JMA hypocenter catalog in which the magnitude was revised in 2003, and reevaluated the parameters to define an effective foreshock activity. We also evaluated the results when the method was applied to the testing period from 1994 to 2009.

The method to select parameters for foreshocks that present high prediction performance consists of four steps. 1) To use the data in which small aftershocks are eliminated. 2) To define a foreshock candidate as the activity that has number of Nf earthquakes with magnitude >= Mf during the period of Tf days in the segment of the size of D x D degree (latitude x longitude). 3) If a mainshock occurs in the period of Ta days after a foreshock candidate occurs, that candidate is treated as true foreshock(s). 4) To search for the values of Mf, D, Nf, and Ta which give high prediction performance by the grid search method. The prediction performance is measured mainly by dAIC, which is defined as the AIC difference between a stationary Poisson model and a model using a foreshock activity, and additionally by alarm rate (AR), truth rate (TR), and probability gain (PG). By applying the above method to the earthquakes occurred in the period of 1980 ? 1993 in the sea area of the northeastern part of Japan, we obtain the best parameters of Mf=5.0 D=0.5, Nf=3, and Ta=3 days for the prediction of mainshocks with M>=6. The prediction performance is expressed as dAIC=74, AR=13% (7/55), TR=19% (9/47), and PG=589. We also found that there is a strong regionality of the foreshock activity and foreshocks defined above are observed only in the regions of off Ibaraki, off Miyagi, and off Iwate prefectures. This suggests that the foreshock activity defined here is not effective in other regions. The performance for these three regions are dAIC=75, AR=58% (7/12), TR=38% (9/24), and PG=458. When we applied this foreshock definition to the data in the period 1994-2009 in three regions, we got the result as dAIC=8, AR=14% (1/7), TR=17% (1/6), and PG=461, which is not so good as expected. The total performance for the period 1980 ? 2009 is dAIC=87, AR=42% (8/19), TR=33% (10/30), and PG=554.

As for off Ibaraki region where characteristic earthquakes with magnitude of 6.7 to 7.2 are known to occur recurrently with the period about 21 years, the long-term probability based on the periodicity is pronounced by Earthquake Research Committee (2009). If we combine the long-term prediction and a foreshock activity defined here, we can make more appropriate prediction. The idea of probability gain will give the total probability. When a foreshock candidate occurs just after the large earthquake, the total probability does not become high, but when one occurs in the period near the next large earthquake, it rises drastically.

Keywords: foreshocks, statistical method, probability gain, along the Japan trench, alarm rate, trueth rate

Japan Geoscience Union Meeting 2011
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SSS024-07 Room:301A Time:May 27 11:00-11:15

Earthquake Occurrence Probability in Inland Japan Modified by the Information of Focal Mechanism Types of Stress Fields

Fuyuki Hirose[1*], Kenji Maeda[1]

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Okada et al. (2010, EPS) found that seismicity in the upper crust is higher just above low velocity zones in the lower crust. They suggested that these low-velocity zones in the lower crust might be caused by the upwelling flow of fluid originating from the mantle wedge. Their observation supports the hypothesis by Hasegawa et al. (2005, Tectono.) that inelastic deformation due to fluids forms the strain concentration zones and promotes the high seismic activities.

Hirose and Maeda (2010, SSJ) researched the relation between epicentral distributions of earthquakes with magnitude (M) $>$ 6.0 and the precise 3D seismic velocity data [Omuralieva et al. (2010, JpGU)]. They found that seismic activity is relatively high in the regions where the seismic velocity at the lower crust near the Moho is lower than the average of that depth. Then they introduced the information of the seismic velocity into the MGR model [Hirose and Maeda (2011, EPS, in press)], and thus produced new earthquake forecast model (MGR-V model). The total performance of the MGR-V model is slightly better than the MGR model.

On the other hand, the Pacific, Philippine Sea, and land plates in Japan have influences mutually and form complicated stress fields. We expect that the precision of earthquake forecast models is improved by incorporating the information of stress fields into those models. Therefore, this study is directed to revise the MGR-V model by taking into account the information of stress fields near seismogenic zone.

We used the information of stress fields divided into three types (normal, reverse, and strike-slip) at the depth of 10 km by Terakawa and Matsu'ura (2010, Tectonics), and combined it with the relationship between epicentral distributions of earthquakes with M $>$ 6.0 and the precise 3D seismic velocity data. We found that, in stress field of the normal type (234/4227, mainly Beppu-Shimabara graben), the relationship between seismic velocity structures and seismic activities is not clear. On the other hand, in stress field of the reverse type (2097/4227, mainly eastern Japan and the Kinki district), seismic activity is relatively high in the regions where the seismic velocity at the lower crust near the Moho is lower than the average of that depth. Furthermore, the similar feature is also observed in stress field of the strike-slip type (1896/4227, mainly eastern Hokkaido and western Japan).

We will revise the MGR-V model by using these results.

Keywords: Earthquake occurrence orobability model, Seismic velocity structure, Stress fields

Japan Geoscience Union Meeting 2011
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SSS024-08 Room:301A Time:May 27 11:15-11:30

Possible periodicity of seismic activity

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Earthquake forecast models are now under testing in Japan. Referring to the seismicity in the past, activity at respective locations can be forecast on the average. However, there are large fluctuations in the actual activity. Although it reflects the fact that a large earthquake will accompany many aftershocks, it is desired to forecast them as much as possible.

In order to evaluate the temporal change in activity, a possibility of periodicity was examined. In the area of all Japan designated by the Japanese test center of CSEP, for example, earthquakes with a magnitude of 5 or greater and a depth of 0 to 100km fairly increased nearly every 10 years, e.g. in 1923, 1933, 1943 and 1952 (the data was based on the Japan Meteorological Agency). Excepting the period around 1963, the activity became remarkable again in 1973, 1982-1983, 1994-1995, and 2003-2004. In most of these periods, there occurred large earthquakes with a magnitude of 8 or close to it.

Considering this periodicity of about 10 years, the next active period may be around 2012-2014. Incidentally, there were exceptional years such as in 1938 and 1968 when the activity was extremely high. Although a forecast model considering the present periodicity improves the likelihood on the average, there is a limitation to the accuracy of the forecast.

The periodical occurrence of earthquakes seems to be found in various regions in the world. But the time and the interval of their active periods are different with each other, suggesting that there are no particular common phenomena with a periodicity same as the occurrence of earthquakes. The length of the interval of active period may correlate with an accumulation rate of elastic strain and its release in the respective regions. According to the discussion for many years more than a century, a periodicity of earthquake occurrence seems not to be accepted widely. However, based on the accumulated reliable data, it may be valuable to consider the possibility and its physical meaning.

Keywords: seismic activity, periodicity, CSEP, Japan, likelihood, strain

Japan Geoscience Union Meeting 2011
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SSS024-09 Room:301A Time:May 27 11:30-11:45

Reason of rare appearance of the seismic quiescence for the crustal earthquakes in the southwestern Japan

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We have reported that seismic quiescence can be recognized at least 10 cases among 25 events in the major earthquakes with the magnitude 6.7 and larger in and around Japan since 1987 in JMA catalog by means of the AkI method (Aketagawa and Ito,2008; Hayashimoto and Aketagawa, 2010). Dividing the above 10 successful cases by focal places, we find 6 cases among 11 events for the plate boundary earthquakes, 3 cases among 7events for the slab earthquakes and only 1case among 7 events for the crustal earthquakes. Dividing the above successful cases of the crustal earthquake by the focal areas, we find that there is one case among one event in the northern Japan, whereas for no case among six events in the central and south-western Japan. Why are they scarcely found in the crustal earthquakes in the southwestern Japan? For this problem, there is a possibility that seismic quiescence cannot be recognized due to different procedures and standards for detection of seismic quiescence. Actually, by applying the AkI method to the Western Tottori-Prefecture earthquake in 2000 (M7.3) with a higher level of the occurrence probability of quiescence, we can detect seismic quiescence before the earthquake (Ohta, personal communication). Therefore, there is a possibility that the cases where quiescence cannot be recognized are caused by use of inappropriate standards. The tectonics of the northern-, central- and south-western Japan are different. The focal mechanisms of the plate boundary and crustal earthquakes in the northern Japan are almost thrust-types, whereas those in the south-western Japan are almost strike-slip types. And those for the central Japan are almost thrust types with high dip angles. Since we search changes in seismic activity for horizontal area in AkI method, the standard should be appropriately changed for the earthquakes with vertical or nearly vertical fault planes.

Keywords: Seismic Activity, Quiescence, Earthquake Prediction

Japan Geoscience Union Meeting 2011
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SSS024-10 Room:301A Time:May 27 11:45-12:00

Recent anomalous changes in temperature and electric conductivity of groundwater at Deyu Hot Springs, Niigata Prefecture

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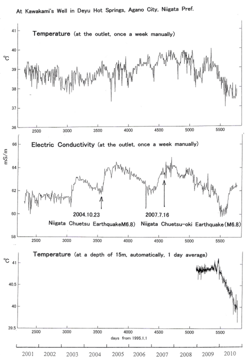
Electric conductivity changes of groundwater, representing the changes on ion concentration, are partly induced by the intrusion of water from deep underground, which is responsible to the crustal stress conditions. Since April, 2001, Mr. Sadao Kawakami has been manually measuring temperature and electric conductivity of groundwater at Deyu Hot Springs, Agano City, in the northern Niigata Prefecture. The measurement is conducted at an interval of one week for the water pumped up from the well. Furtherrmore, we have temperature data measured automatically since December 7, 2008. The conductivity was almost constant at a level of 60-62mS/m untill around June, 2003, when the conductivity initiated to rise. The peak value of 63mS/m is recorded around the period between August and November, 2003. While decreasing after the peak period, the conductivity turned to rise responding to the 2004 Niigata-ken Chuetsu Earthquake of M6.8 with the maximum at 64mS/m in around January, 2005 and decreased gradually. Around March, 2007 it tended to rise again followed by the 2007 Niigata-ken Chuetsu-oki earthquake of M6.8 on Sep.16, 2007. The above phenomena suggests stress concentrations taking place in the crust before large earthquakes, which may generate highly compressed fluids within cracks in the rocks. Those fluids tend to migrate upwards through crack system in the crust. Among them, the intrusion of water with high concentration of ions into a shallow water reservoir results in an increase in the conductivity of the water. Rise of conductivity is accompanied by temperature rise for the above cases. Around the end of 2009 the conductivity started to decrease with clearly decreasing temperature, indicating stress relaxation underground. Hoewever, the recent rise of the conductivity since the end of May, 2010 is not with increase of temperature. The origin of the water of decreasing temperature tended to be different from that of increasing conductivity. Anyway, neawly activated stress changes are going on in the Niigata area.



Keywords: groundwater, groundwater temperature, electric conductivity, earthquake prediction

Japan Geoscience Union Meeting 2011
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SSS024-11 Room:301A Time:May 27 12:00-12:15

A quantification of witness evidences before the 1946 Nankai earthquake

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A long term vertical crustal movement before the 1946 Nankai earthquake was been obtained by combined two kinds of data which were the leveling by the Geographical Survey Institute(GSI) and the survey by the Hydrographic Bureau(HB). Just before the 1946 Nankai earthquake, many witness evidences such as decreased well water were collected by Umeda and Itaba(2010). At Saga district of Kuroshio town in Kochi prefecture, the subsurface water structure was investigated and an equation of d{sup}2{/sup}=90.8h was obtained based on the model presented by Umeda et.al.(2010). d is an amount of decreased well water and h is a vertical crustal change. This relation suggests that a crustal uplift of 0.05m induces a 2.1m decrease in well water.

Keywords: 1946Nankai earthquake, witness evidences

Japan Geoscience Union Meeting 2011
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SSS024-12 Room:301A Time:May 27 12:15-12:30

Statistical Analysis of relationship between geomagnetic index (AE, Dst) and earthquake-days in Japan and its vicinity

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[1]JAXA/ARD/ Space Environment Group

The AE index and the Dst index (UT) on the earthquake-days (days(JST) when earthquakes with M5 or greater (aftershocks are not included.) occur in Japan and its vicinity) and those on non-earthquake-days are compared for 1963-2009. The years when the average AE on earthquake-days is greater than that on non-earthqukae days are 33 years of the total 44 years. The years when the average Dst on earthquake-days is smaller (negative, absolute value is greater) than that on non-earthqukae days is 32 years of the total 47 years. This result shows that the global geomagnetic disturbance is greater on the earthquake-days in Japan and its vicinity than that on non-earthquake-days.

Keywords: earthquake-day, in Japan and its vicinity, geomagnetic index, AE index, Dst index, statistical analysis

Japan Geoscience Union Meeting 2011
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SSS024-13 Room:301A Time:May 27 12:30-12:45

Mechanism of generating electromagnetic fields just before great earthquakes

Kozo Takahashi[1*]

[1]None

Background: The potential of the ionosphere is about a few MV, and from the ionosphere to the ground about 1.4 kA current is flowing. This positive current is compensated by the negative current generated by thunderclouds. As Figure shows, where solid lines show air flow and broken lines show loci of ice crystals and hails, in normal thunderclouds hails are negative and crystals are positive, where -10 degrees or lower. On the other hand where -10 deg. or higher, hails are positive and crystals are negative. The reason is explained as follows:{cr/}

The melting temperature of solid matter is lower on the surface than the inside, and at -10 deg. the surface of crystals is liquid. The inside of crystals there are free electrons and positive holes, and the electrons can move to the surface water, but the holes can't, so the water is negative, and the solid part of crystals is positive.{cr/}

In thunderclouds crystals collide with each other. Where lower than -10 deg., the collision approximates to elastic one. Then the positive water on the smaller crystals moves to the lager crystals, the smaller crystals become positive and are blown up by an ascending air current. At the cloud top of about 10 km high, the voltage becomes up to about 30 MV. As the electric conductivity between the cloud top and the ionosphere is relatively larger than that between the cloud bottom and the ground surface, and as the potential at the cloud top is much higher than at the ionosphere, so electrons and negative ions flow from the ionosphere into the cloud top, and the flow keeps the ionosphere charged at a few MV. Where higher than -10 deg., crystals are soft and will crush or to pieces when they collide.{cr/}{cr/}

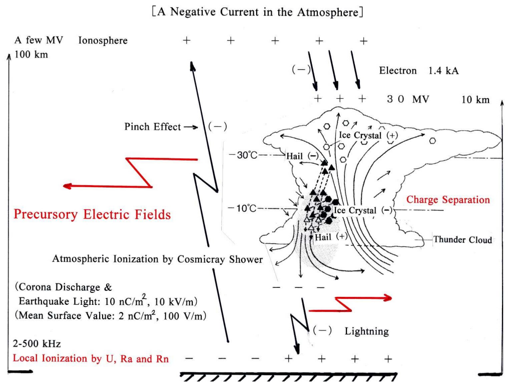
Mechanism generating precursory electric fields: The trace of lightning is zigzag, because the discharge flows along the trace of cosmic ray showers. The current between the surface and ionosphere also flows along the trace of cosmic ray showers, but it is usually invisible, as the resistance in the low atmosphere is large.{cr/}

About one week before S Hyogo Pref. Eq. (1995/01/17 M: 7.2), the column of cloud like a small tornado was observed, which extended vertically from the source region up in the sky, though strong wind was blowing then. At the same time, the density increase of radioactive Radon (Rn) was observed in the spring water and low atmosphere on the source region. This increase makes the conductivity higher locally and tentatively in the low atmosphere, and makes the current increase between the atmosphere and ionosphere, and the current density increases by Pinch Effect. This current must generate the tornado-like cloud, which is similar to the cloud in Wilson cloud chamber.{cr/}

The current between the surface and ionosphere, mentioned above, is pulsating current, as the trace of cosmic shower changes rapidly in time and space, so the current radiates wide band radio-waves, which must be observed as precursory seismic electric fields.{cr/}

Rn and Radium (Ra) are generated by decay of Uranium (U), and U exists in crystal boundary. If micro-cracks run in the source, U, Rn and Ra dissolve into pore water, and the pore water mixes in spring water. So, the micro-cracks generate the free electrons, ions, charged aerosols above the source regions, which are accompanied by many precursors, such as precursory fields.{cr/}{cr/}

Reference: Clouds being accompanied by thunder & Clouds being not accompanied by thunder (in Japanese), Tsutomu Takahashi, Kagaku, Sep. 2010, Vol. 80 No. 9, pp. 916-917



Keywords: earthquake prediction, precursory seismic electromagnetic fields