Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SCG66-P01 Room:Convention Hall Time:May 24 16:15-17:30

Mud volcanism and thermal structure in the western Mediterranean Ridge accretionary complex (Eastern Mediterranean)

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Submarine mud volcanoes are discovered in most subduction zones of the world, and those developed on accretionary prisms are considered to document material recycling and fluid migration within the prisms. The Eastern Mediterranean has numerous mud volcanoes, most of which develop on contiguous belt within the Mediterranean Ridge (MedRidge) accretionary complex. However, mud volcano fields in the western MedRidge remain poorly studied, although those in the central and eastern MedRidge have been heavily surveyed during an Ocean Drilling Project or European projects. This study aims at understanding material recycling and fluid migration within the western MedRidge accretionary complex. In order to achieve this objective we delineate possible ascent style of the ejecta forming the Medee-Hakuho Mud volcano (MHMV) in the western MedRidge, by applying the vitrinite reflectance technique to ejecta samples retrieved by ROV NSS (Navigable Sampling System) during KH-06-4 Leg 6 Cruise.

First, we modeled the 2-D thermal structure in the western MedRidge taking into account frictional heating on the plate interface for estimation of the source depth of the ejecta from MHMV. The result suggests an effective coefficient of friction of less than 0.05, and a temperature of about 120+/-15^{o}C along the plate interface at a distance of 180 km from the deformation front, the location of a seaward toe of the Aegean backstop. Second, we evaluated the source depth of the ejecta from MHMV using vitrinite reflectance based on the modeled thermal structure. The result suggests that the ejecta matrix showing vitrinite reflectance (VR) values of about 0.59% was derived at a temperature of around 85^{o}C, corresponding to a depth of approximately 5.5 kmbsf, whereas the clasts (e.g., shales and siltstones) representing VR of ~0.6-1.0% were derived from much deeper depths. Most of the (pre-)Aptian clasts were considered to have been jacked up to the depth of 5.5 kmbsf due to underplating at the toe of a rigid backstop that had developed below MHMV after underthrusting due to plate subduction. At that depth, fluid pressure may have been dramatically increased due to underplating, and consequently fluid-rich sediments accompanying surrounded clasts ascended through an existing backthrust.

Keywords: mud volcano, thermal structure, Mediterranean Ridge, Eastern Mediterranean

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A direct method for estimating the rigid body motion of crustal blocks from GPS velocity data

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The Japanese Islands is composed of many crustal blocks (e.g., Taira, 2001). GPS array data contain information about not only rigid body motion (translation and rotation) of the crustal blocks but also intrinsic deformation due to fault slip at their boundaries. For this reason, McCaffrey (2002) proposed an inversion method to simultaneously estimate rigid block motions and fault slip rates at block boundaries from GPS velocity data. However, as demonstrated by Noda et al. (2013), rigid body motion and intrinsic deformation are separable from each other. In fact, rigid body translation and rotation are the constant parts of velocity and rotation fields, respectively, and both of them are independent of intrinsic deformation (strain). This means that we can estimate rigid block motions and fault slip rates independently of each other from GPS velocity data. In this study, we propose a direct method for estimating the rigid body translation and rotation of a crustal block from GPS velocity data with bidirectional polynomial fitting in Chebyshev form, and examine its validity through the analysis of interseismic GPS velocity data (1996-2000) in southwest Japan.

References

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Keywords: GPS data, rigid block motion, Chebyshev polynomials, direct estimation

SCG66-P03 Room:Convention Hall Time:May 24 16:15-17:30

Relative plate motion on plate interface considering intra-plate deformation

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1. Introduction

Evaluating earthquake potential requires knowing relative plate motion on the plate interface. Generally, several previous studies used the relative plate motion velocity, which is rigid plate motion using Euler pole. Actually, subducting plate has intra-plate deformation, such as bending-unbending, uniaxial elastic deformation, isotropic compression and so on. In this study, we estimate relative plate motion velocity on the plate interface with intra-plate deformations.

We proposed the estimating method of the relative plate motion velocity on the plate interface with the intra-plate deformation (Sasajima and Ito, 2012, Meeting of the geodetic society of Japan). In this study, we present spatial distribution of relative plate motion velocity on the Pacific plate interface with intra-plate deformation.

2. Method

A changing of relative plate motion velocity on the plate interface relates strain rate with intra-plate deformation. We describe quantitatively strain rate due to the intra-plate deformation. In order to describe quantitatively strain rate, we use an orthogonal curvilinear coordinate system, that X-axis is along the direction of subducting plate and Z-axis is orthogonal of X-axis. In this study, we consider three types of intra-plate elastic deformations as follow

[1] Bending-unbending

[2] Uniaxial tension or compression along direction of subducting plate motion

[3] Isotropic compression

So, we convert strain rate to plate motion velocity change, we obtain the velocity changing due to intra-plate deformation.

3. Result

We adapt this method to the subducting Pacific plate beneath Tohoku region. In consequence, we reveal that the estimated subducting velocity on the plate interface is about 10 ~ 20 percent faster than rigid plate motion velocity at large curvature of plate interface. Especially, the estimated subducting velocity is about 25 percent faster than rigid plate motion velocity at eastern Hokkaido region. The subducting Pacific plate at eastern Hokkaido is stretching along dipping direction. Moreover, our result is well consistent with the extensional velocity of outer-rise region, which is derived from displacement rate of normal fault [Iwabuchi, 2012, Zisin,65-1,9-20].

{Acknowledgement}

We use the JODC-Expert Grid data for Geography -500m and ETOPO1 produced by NGDC. Thank you very much for their courtesy.

Fig. Color contour is relative velocity of Pacific plate to North-America plate considering intra-plate deformation. Initial rigid rotation is given by ITRF2005. Blue solid line denotes the Japan Trench. Red solid line is deeper limit line which inter-plate earthquake occurs [Igarashi, 2001]. Black solid line is denotes the East-Western margin of subducting Phillipine Sea Slab [Uchida et al., 2009]

Keywords: Plate tectonics, Subducting velocity, Subduction zone, Bending-Unbending, Intra-plate deformation

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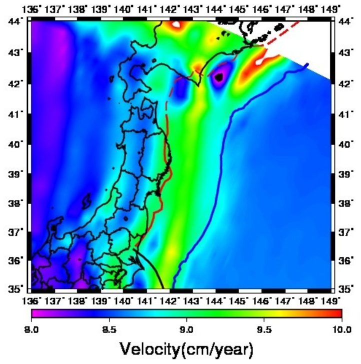

SCG66-P04 Room:Convention Hall Time:May 24 16:15-17:30

Modeling of the high strain zone along the eastern Japan Sea margin.

Hirofumi Mase[1]*

[1]none

If the temperature of a subducting plate is low, high temperature areas are generated on and under it. They tighten the subducting plate from both sides by pulling against mutually. A plate convergence zone forms and maintains the temperature structure. And the opposite can be said too. I have insisted on this (1)(2). I will call the subducting plate B, and upper and lower high temperature areas "A" and C respectively. Mantle "A" of high temperature is pushed from the far west by companion and pulled by C downward in the eastern. Because "A" is pressed against B, "A" tries to climb B along its slope. It climbs until equiponderating to the resultant force of gravity and pressure from the upper side and the east. Afterwards, because it stagnates sidles up up, the land is formed. There are many features in our Islands. (a)Is the Tohoku and the Japan Sea why typical arc and basin? (b)Why do active volcanoes exist even to the west in Hokuriku-North Kanto and does the land project too?(37deg.N-36deg.N) (c)Why can the Chugoku lie, and why doesn't it become a basin in the vicinity of 35deg.N? I explained these mysteries (3).

I think about the high strain zone along the eastern Japan Sea margin. Though by pulling against mutually "A" heads eastward and C to which B is put heads westward, I showed that a neutral line in surface appeared on the west side of Japan Trench because the heading eastward element was counterbalanced in the wedge part (1). However, the neutral line is only an appearance if strain because of shrinking has been distributed to the whole area. If strain concentrates on the narrow scope, it's a high strain zone. The deformation by mutually pulling against happens chiefly in uppermost mantle. It is important to clarify the difference between that and surface deformation for the understanding of geographical features and earthquakes. It is difficult to make the whole image of A,B,C a model and to reproduce it by experiment. It becomes possible by the simplification only for the part where "A" starts climbing the slope of B.

The model is composed of the container(300H520W30D) with contents and front side of transparency. In it, the slider with a slope does the slide horizontally on the bottom from right to left so that it may raise the brown rice kernel("A") by scooping. The curve of the slope must become walled steep slope in which it suddenly stood up to express the congestion of "A" though the main is loose. If the slope does the slide to left(west), "A" heads eastward relatively, climbs the loose slope, knocks against the steep slope, sidles up up, and forms mountain. A basin is beyond the limits of the west side of this device. The east from center of land is beyond the limits of the east side. The matter that "A" climbs the slope and competes of congestion, in a word, "From offshore in Japan Sea To center of Tohoku" is approximately expressible.

To know the movement of the surface of "A", it only has to put one chain beforehand. Result of the slider's doing slide, on the surface of "A", the left half became a loose slope and the right half became a slope in mountain to the top though it was horizontal first. The chain has shrunk most in the foot in the mountain. Remarkable shrinkage has been generated between sea and mountain in a word. This result harmonizes with the existence of the high strain zone along the eastern Japan Sea margin.

(1)[Mase]http://www2.jpgu.org/meeting/2007/program/pdf/S149/S149-005.pdf
(2)[Mase]http://www2.jpgu.org/meeting/2012/html5/PDF/S-CG67/SCG67-P06.pdf
(3)[Mase]http://homepage3.nifty.com/hmase/upload120509web.htm

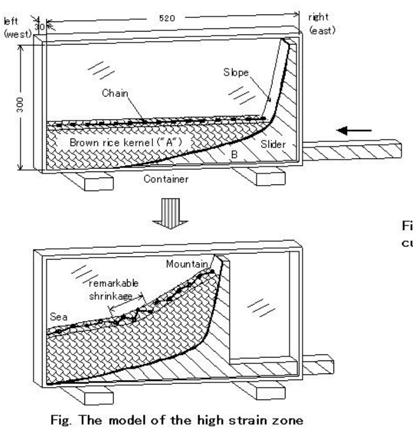

Fig. The model of the high strain zone

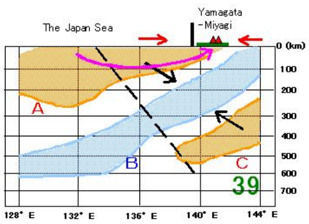

Fig. The temperature structure cross section cutting 39deg.N (3)

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Time-dependent crustal deformation associated with the 2004 Chuetsu and the 2007 Chuetsu-Oki earthquakes

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There is an ongoing concentrated deformation along the Japan Sea coast, which has been identified as Niigata Kobe Tectonic Zone (Sagiya et al., 2000). Large historical earthquakes have occurred in this area, and in recent years, Niigata has suffered the impact of two important events, known as the 2004 Mid-Niigata Prefecture earthquake (MJ 6.8) and The 2007 Niigata-ken Chuetsu- Oki earthquake (MJ 6.6), which considerately affected the crustal deformation pattern. For this reason, we review temporal variation of crustal deformation pattern in the mid Niigata region based on daily coordinates of 28 GPS sites from the GEONET network for three time windows: before 2004, 2004-2007 and after 2007 until March 2011, to avoid the post deformation associated with Tohoku-Oki earthquake. We observed a migration of the deformation pattern in the East-West direction through the contraction belts for the above time windows. Before 2004, we can recognize a clear shortening of 0.3ppm/yr in the area between the source regions of 2004 and 2007 quakes. After the 2004 Chuetsu earthquake, this shortening rate decreased. On the other hand, an accelerated contraction occurred to the east of this region, around the source region of the 2004 earthquake. After the 2007 earthquake, another contraction zone appeared to the northwest, near the 2007 source region. These time-dependent behaviors suggest there exists strong interaction between parallel fault segments in this area. It is crucially important to reveal such interaction to understand crustal deformation and seismogenesis in this region. We construct kinematic deformation models to interpret the time-dependent deformation pattern for each time period and to investigate mechanical interaction of coseismic as well as probably aseismic fault slips.

Keywords: Crustal deformation, Niigata Kobe Tectonic Zone, Kinematic model, Aseismic fault slips, GPS measurement

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Subduction zone categories based on the slab age gradient

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In general, it seems that possible factors which would correlate with the category of subduction zones, are slab thickness (thickness of the elastic core), the negative buoyancy force of sinking slab, surrounding upper mantle flow regime, physical properties of the surrounding upper mantle (esp., the viscosity), the presence or absence of stagnated slab at 670km depth, stagnated slab volume at 670km, slab stagnating or penetrating at 670km, global-scale dynamic constraint of the subduction zone distribution, absolute plate motion of overriding lithosphere, spherical slab buckling, convergence of the buoyant linear topography, gradient of slab age, and others.

We, here, present new treatment on the classification of subduction zones, mainly focused on the age gradient of downgoing oceanic slab. One of the other factors to be incorporated during the classification is the absolute motion of overriding lithosphere. For simplicity, hereafter we assume zero absolute plate motion for the overriding lithosphere.

Numerical studies on the buckling mode of spherical shell on the earth (e.g., Mahadevan et al., 2010) suggest that the mechanical buckling wavelength of subduction zone segments is not a continuous but a discrete function of slab age. For example, the trench-parallel length of the subduction zone segment with the slab age of ~135Ma is approximately twice as large as that of the segment of ~20Ma. Mechanical state of subduction zone segment with the slab age between ~20Ma and ~135Ma is rather ambiguous. For the case of the convergent segment with the increasing (or decreasing) slab age, transitional response constrained by spherical buckling would provide additional horizontal stress component being trench-normal compressive (or less-compressive).

The slab age gradient might be important for understanding the evolutionary process of lithosphere convergence on the Earth.

Keywords: subduction zone category, slab age gradient

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Differential geometry of folding and fracturing of crust

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When the Riemannian manifold of $\mathbf{V}_n$ dimension with non-zero Euler-Schouten curvature tensor exists in the enveloping manifold (Euclid space) of $\mathbf{V}_m$ dimension, the including Riemannian manifold of $\mathbf{V}_n$ protrudes into the enveloping manifold of $\mathbf{V}_m$ dimension. From the Euler-Schouten curvature tensor and force-balance equation, Kondo (1955) derived a unified theory on yielding or buckling of plates or shells. By using this concept of protrusion into high order spaces, we present a unified equation on yielding or buckling of crust.

Keywords: Euler-Schouten curvature tensor, Riemannian manifold, crust, fold, fracture

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Spatio-temporal renewal model for repeating earthquakes and analysis of slip rate on plate boundaries

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We propose a new spatio-temporal stochastic model based on a renewal process and analyze repeating earthquakes on the upper surface of the subducting Pacific Plate to estimate spatio-temporal transition of slip rate on the plate boundary.

A renewal process is a point process that assumes intervals of events are independently and identically distributed. It is applied to long-term forecast of large earthquakes in active faults or on plate boundaries.

But when we apply it to small repeating earthquakes, the assumption of stationarity in renewal processes often fails because their intervals are influenced largely by the change in slip rate near their hypocenters.

Thus, we consider a non-stationary renewal process that the repeating intervals are inversely proportional to their neighbourhood slip rate. We introduce the space-time structure into this model by smooth cubic B-spline functions allocated to partitioned grids. On estimating the coefficients of spline bases, we use a penalty function for unsmooth change into the model to avoid over-fitting for the dataset. Optimal hyper-parameters are selected by Akaike's Bayesian Infromation Criteria (ABIC). We use relations by Nadeau and Johnson (1998) to convert the magnitudes and intervals of repeating earthquakes into the absolute slip rate.

We apply proposal model to the dataset of repeating earthquakes on subduction zone of Pacific Plate and estimate slip rate history of plate boundary. We see the characteristic changes in slip rate before and after the major earthquakes such that Sanriku-Haruka-Oki (1994 M7.6), Tokachi-Oki (2003 M8.0), Kushiro-Oki (2004 M7.5), Fukushima-Oki (2008 M6.9), Ibaraki-Oki (2008 M7.0) and large foreshocks of Tohoku-Oki (2011 M9.0).

Proposal model can estimate slip rate at depth where GPS system can not measure directly. Although it is difficult to estimate coseismic slip of large earthquakes from repeating earthquakes, this model may be useful to monitor the transition of stress field or interplate coupling on plate boundaries.

There remains a problem that the afterslip of large earthquakes and slow slip events should be discriminated.

Keywords: repeating earthquake, Tohoku-oki earthquake, slip rate, spatio-temporal model

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Change of crustal deformation around Shizuoka after 3-11

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1. Introduction

2011 March 11 M9.0 occurred off Tohoku district in the Pacific Ocean. It made a large crustal deformation at the occurrence in all over Japan. After the event, still more the after deformation was observed in wide area. Then we research the characteristics of crustal deformation around Shizuoka prefecture using GPS data by GEONET. The softwares MICAP-G developed by MRI, and PAT-ME by K. Nakamura were used for this research.

2. Analysis

Large uplift and subsidence after 3-11 event were observed in Tohoku and north Kanto regions. This deformation pattern was explained by the non-earthquake slip at the deep part of the plate boundary. In Chubu region, uplift pattern was clearly separated by Fossa Magna and it means the deformation occurred in each micro-plate individually. Around Shizuoka prefecture, the longitude change was analysed. Temporal change of stations in Izu peninsula were some different from the ones of stations in Shizuoka prefecture. It means that the long term trend of location in Amurian plate was changed from one of Philippine Sea Plate in late 2012.

We thank A. Kobayashi distribute the correction data of GPS.

Keywords: Tokai earthquake, crustal deformation, after effect