Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SCG68-P01 Room:Convention Hall Time:May 20 13:45-15:15

Water level and temperature change of geothermal spring as a good indicator of a vectorial change of the local stress

KAWABE, Takayuki[1*], NAKANO Keiji[2]

[1]Faculty of Education, Art and Science, Yamagata University, [2]Terra-Fluid Systems

Water lebel and its temperature are changed at some geothermal wells located in Yamagata, southern Fukushima and northern Ibaraki Prefectures just after the 2011 off the Pacific coast of Tohoku Earthquake. Most of them are beared in fractures.

Such change of lebel and temperature of geothermal wells beared in fractures by a large earthquake is well known at previous large earthquakes as the Southern Hyogo Prefecture Earthquake in 1995 and the Niigata Chuetsu Earthquake in 2004, etc.

Water level and its temprature increase when the secondary local stress by a deformation of the surficial crust by the quake effects compressionally to the water-bearing fractures, and they decrease when the secondary local stress effects reratively tentionally to the fractures.

Thus the change of water level and its temprature of the geothermal wells beared in the fractures is a good indicator of a vectorial change of the local stress field.

Keywords: Water level and temperature change of geothermal spring, vectrial change of local stress field

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SCG68-P02 Room:Convention Hall Time:May 20 13:45-15:15

Crustal stress around Shikoku and Kii region derived from the construction of integrated groundwater observation network

SATOH, Takashi[1*], KITAGAWA, Yuichi[1], SHIGEMATSU, Norio[1], TAKAHASHI, Makoto[1], TSUKAMOTO, Hitoshi[1], KIGUCHI, Tsutomu[1], ITABA, Satoshi[1], UMEDA, Yasuhiro[1], SATO, Tsutomu[1], Yoji Seki[1], KOIZUMI, Naoji[1]

[1]GSJ/AIST

GSJ/AIST has been constructing the integrated groundwater observation network around Shikoku and Kii region for forecasting the Tonankai and Nankai earthquakes since 2006FY, and fourteen stations have already been completed. Three observation wells with different depths, usually 30, 200 and 600m, were drilled at each station. Various information about shallow crustal stress was derived by experiments using these boreholes and the drilled cores.

Hydraulic fracturing stress measurements were conducted in the 600m borehole of five stations, where granitic rock was drilled. Flow rate and water pressure were monitored just above the measurement interval to measure the reopening pressure precisely. The measurements were succeeded over a wide range of depths at the station in Toyota, Aichi prefecture, and a reverse fault type stress field with E-W to NE-SW maximum horizontal stress direction was obtained.

Borehole breakout (BB) and/or drilling induced hydraulic fracturing (DIHF) were found at eleven stations on the borehole wall images produced using borehole televiewer/camera. The direction of maximum horizontal stress derived from BB and DIHF as well as the hydraulic fracturing stress measurements ranges between E-W and NE-SW for almost all the stations. This stress direction is perpendicular or largely oblique to the relative convergence direction of Philippine Sea plate to Amour plate. Our results are roughly consistent with the previous stress measurements as well as the focal mechanisms of shallow crustal earthquakes in this region. We are examining the orientation distribution of fractures and its relation to the stress orientations reported here.

Keywords: Shikoku and Kii region, Shallow crustal stress

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SCG68-P03 Room:Convention Hall Time:May 20 13:45-15:15

Estimation of crustal stress orientations from long-term trends of borehole strainmeters around Kii and Shikoku regions

KIGUCHI, Tsutomu[1*], KUWAHARA, Yasuto[1], MATSUMOTO, Norio[1], KOIZUMI, Naoji[1]

[1]GSJ, AIST

Long-term trends measured by borehole strainmeters can be interpreted as the relaxation process of stress disturbance caused by a borehole drilled in stressed rock mass. On the base of this model, the differences of long-term deformations in different orientations are due to an anisotropic stress field so that a borehole is compressed in the direction of maximum horizontal stress. Geological Survey of Japan, AIST has been constructing 14 integrated borehole observation stations in and around the Kii Peninsula and the Shikoku Island since 2006. Crustal strains are being observed with 4-component borehole strainmeters deployed at each station. In this study, we examine the long-term strain measured at each station from a view point of the model of the relaxation process due to stress disturbance by boreholes, and try to estimate the orientation of the maximum horizontal compressive stress by applying this model to strain data.

Firstly we use the strain data of about 700 - 1600 days up to September 2011 since instrument installations at 13 stations, where the strainmeter data were calibrated by comparing actual and theoretical tidal strains with a method of Matsumoto et al. (2011). Secondly, an average strain of 4-component data is extracted from original data to analyze only the anisotropic stress field. Thirdly we calculate the azimuthal distribution of relative change in radial 4 components during 90 days. As radial strain varies with cos2x as shown by this model, we fit a curve of cos2x to the relative change of strain and determine the orientation of maximum compression from the direction of minor axis of a fitted curve, where x is the angle between maximum horizontal stress and strain gauge. Finally time-varying stress orientations are obtained throughout the entire observed period by moving a time window of 90 days by each one day. The obtained stress orientations are nearly constant in time within a standard deviation of 2 degrees for 9 stations, while the orientations obtained at the other stations show large fluctuations. The stress orientations estimated at the 9 stations are not definite but rather dispersed, being distributed from northeast to southeast. We will compare the stress orientations estimated from this method with other results by hydraulic fracturing, stress-induced wellbore failure and anelastic strain recovery at each station to examine a validity of the proposed method in the next step. Further we will test a viscoelastic model or a poroelastic one to understand a mechanism of the long-term trend of the borehole strain data.

Keywords: crustal stress orientation, borehole strainmeter, long-term trend, Kii Peninsula, Shikoku Island

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SCG68-P04 Room:Convention Hall Time:May 20 13:45-15:15

Analysis Stress Field Heterogeneity by Using Logging Data

SHIBANUMA, Jun[1*], YAMADA, Yasuhiro[2], Toshifumi Matsuoka[2]

[1]Graduate School of Engeneering, Kyoto University, [2]Depertment of Urban Management Engineering, Kyoto University

In general, it is considered that underground stress field is almost homogeneous. Thus stress state, which is measured locally, is identified as representative stress in whole area. However, it can be predicted that stress state is complicated around discontinuities like fault. So I tried to analyze how stress state is fluctuated around fault by logging data at Nankai Trough. I estimated principle stress direction and range of that magnitude from borehole failures.

I found that principle stress direction is rotated around fault. Maximum stress direction is rotated to parallel with surface of fault outside of fault zone, where is softer than around rock, and rotated to normal to the surface inside. And magnitude of stress is increasing outside of fault zone, and decrease inside. And it can be considered that such fluctuation of stress state is caused by difference of rock properties between outside and inside of fault.

Keywords: Stress, logging, Nankai Trough, LWD, borehole breakout

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SCG68-P05 Room:Convention Hall Time:May 20 13:45-15:15

Transitional patterns of crustal stress field between Honshu arc and Ryukyu arc in Japan

OTSUBO, Makoto[1*], KUBO, Atsuki[2]

[1]Geological Survey of Japan/AIST, [2]Kochi University

Deformation and stress state in active island arcs are important for understanding the dynamics. We analyzed crust stress state in the connective region between Honshu and Ryukyu arc to understand the transitional stress between with and without backarc opening of the arcs around southwestern Japan arc. In this study, we apply the multiple inverse method (Otsubo et al., 2008) into the focal mechanism solutions (best double couple components of regional moment tensors derived by F-net, NIED, Japan) in the area. The data were obtained from about ˜400 shallow earthquakes (< 20 km) since January 1st, 1997 to December 31th, 2010. All local magnitudes were greater than 3.0. As a result, the multiple inverse method shows different stress province from one found by P-/T- axes. In perspective view, Shmax and Shmin directions rotate gradually from Honshu to Ryukyu. This result constrains patterns of the fan shaped stress trajectory between compressive Honshu arc and extensional Ryukyu arc, which is important issue to the understand geodynamics of subduction zone island arc. In addition, the multiple stress solutions and these stress ratio variations indicate locally heterogeneous stress states between Honshu arc and Ryukyu arc.

Acknowledgements:
Thanks are also due to the National Research Institute for Earth Science and Disaster Prevention (NIED) for making available the focal mechanism data in the study area.

Reference:
Otsubo, M., Yamaji, A. and Kubo, A. (2008) Determination of stresses from heterogeneous focal mechanism data: An adaptation of the multiple inverse method. Tectonophysics, 457, 150-160.

Keywords: Focal mechanism, Stress, Subduction, Stress tensor inversion, Earthquake, Kyushu

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SCG68-P06 Room:Convention Hall Time:May 20 13:45-15:15

Parametric and non-parametric methods of determining paleostress from dykes or veins

SATO, Katsushi[1*], YAMAJI, Atsushi[1], TONAI, Satoshi[2]

[1]Div. Earth Planet. Sci., Kyoto Univ., [2]AIST

Orientaions of dykes and veins are clues to ancient tectonic stress states. Newly formed open fractures in intact rock masses are expected to be perpendicular to the minimum compressive principal stress ($sigma_3$) axis. Jolly and Sanderson (1997) extended this concept for re-opening of pre-existing fractures. Their model allows us to infer orientations of three principal stress axes and stress ratio $Phi=(sigma_2-sigma_3)/(sigma_1-sigma_3)$, and it provides a basis for the determination of stress magnitudes (Andre et al., 2001). The difficulty of this method is in the recognition of border of orientation range since the frequency of fractures gradually decreases toward the border in most cases. Yamaji et al. (2010) solved this problem by fitting the Bingham (exponential) distribution to the orientational frequency of fractures. This method need not specify the border of orientation range. The basic assumption of their method is the monotonous decrease of fracture frequency against the tectonic normal stress.

However, there can be a fracture distribution of which frequency decreases not exponentially. This study proposes two modified methods. One employs a shifted power type of stochastic model, which has a larger degree of freedom and can express various types of decreasing function flexibly. It should benoted that the shifted power model has an advantage in determining reletive value of fluid pressure $lambda=(P_f-sigma_3)/(sigma_1-sigma_3)$, where P_f is the fulid pressure. Another modified method is non-parametric and does not use a stochastic model. This method searches for an optimal stress state which minimizes the rank correlation coefficient between fracture freqnencies and normal stress magnitudes at all possible orientations. The advantage is in the exclusion of extra assumption on the type of orientation distribution.

For the purpose of testing the new methods, we analyzed simulated fracture datasets. Firstly, the three methods were applied to a simulated dataset obeying a Bingham distribution. As results, correct principal stress orientations and stress ratio were commonly obtained within confidence ranges. The precisions and accuracies of Bingham and shifted power models were equvalent and higher than those of non-parametric method. Secondly, a simulated dataset obeying stepwise distribution were analyzed to find that the shifted power model was superior to the other two methods in precision and accuracy. Consequently, the shifted power model generally performs well, while the non-parametric method is also useful with acceptable precision for its fewer assumptions.

We applied the methods to the Early Miocene andesitic dyke swarm intruded into Mino-Tamba Belt around Tsuruga city, Fukui Prefecture (Hoshi and Takagawa, 2009). The three methods commonly resulted in a normal-faulting stress regime with a NW-SE trending sigma_3 axis. The precisions of Bingham and non-parametric methods were similar, while that of shifted power method was superior to them. The type of frequency distribution of dykes was nearly linear, and a stress ratio of Phi=0.66+0.19/-0.22 and a relative fluid pressure of lambda=0.76+0.06/-0.16 were obtained. Although the shifted power model cannot deal with a complicated frequency distribution in comparison to non-parametric method, it is useful for the objective determination of relative fluid pressure which is an important parameter to investigate crustal dynamics.

References

Andre, A.S., Sausse, J. and Lespinasse, M., 2001, Tectonophys., 336, 215-231.
Hoshi, H. and Takagawa, M., 2009, Jour. Geol. Soc. Japan, 115, 96-99.
Jolly, R.J.H. and Sanderson, D.J., 1997, Jour. Struct. Geol., 19, 887-892.
Yamaji, A., Sato, K. and Tonai, S., 2010, Jour. Struct. Geol., 32, 1137-1146.

Keywords: stress tensor inversion, dyke, vein, fluid pressure, non-parametric statistics

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SCG68-P07 Room:Convention Hall Time:May 20 13:45-15:15

Paleostress analysis using healed microcracks in the Ryoke granites, southern Chubu District.

KANAI, Takuto[1*], AIZAWA, Shinsuke[2], TAKAGI, Hideo[1]

[1]Waseda University, [2]Nittetsu Mining

Paleostress analysis using 3-D orientation distribution of healed microcracks (HC) in quartz grains was carried out for the Ryoke granites in the southern Chubu District, central Japan. From the previous microthermometry analyses on the fluid inclusions forming HC in the Ryoke (Toki) granite (Takagi et al., 2008), the healing temperature were estimated about 300-400deg.C near the blocking temperature for the K-Ar system of biotite. The samples analyzed are Busetsu, Inagawa and Obara granites that are distributed between previously analyzed Shinshiro tonalite and Toki granite bodies in which the sigma-3 orientations of HC are very different in both granitic rocks (Aizawa and Takagi, 2008, Takagi et al., 2008). The orientation distributions of HC show two or three maxima nearly orthogonal each other. This orthogonal concentration pattern is probably due to the transposition of principal stress during microcrack formation. To clarify the orthogonal concentration pattern, we used cluster analysis and reconstructed sigma-3 orientations. The angles of sigma-3 orientations with respect to the strike of the Median Tectonic Line (MTL) tend to increase gradually towards the MTL from around 30deg. plus or minus 40deg. in the Toki granite (northernmost) to 83deg. plus or minus 27deg. in the Shinshiro granite (southernmost) near the MTL.

The sigma-Hmax orientations (normal to the sigma-3 orientation on the horizontal plane) intersect the strike of MTL at a distance from the MTL in the Toki and peripheral areas suggest the regional compressive stress field caused by the movement of subducting Pacific Plate at early Paleogene (K-Ar biotite ages for the Toki granite). On the other hand, sigma-Hmax orientations subparallel to the strike of the MTL near the MTL suggest the changes in stress field by the activity of the MTL and/or the influence of the uplift of the high-P/T type Sanbagawa metamorphic terrane underlying the Ryoke terrane by the MTL (Takagi et al., 2008).

References

Aizawa, S. and Takagi, H., 2008, Paleostress analyses and estimation of bending of the Median Tectonic Line using healed microcracks from the Ryoke granites. The 115th Annual Meeting of the Geological Society of Japan, 221.

Takagi, H., Miwa, S., Yokomizo, Y., Nishijima, K., Enjoji, M., Mizuno, T. and Amano, K., 2008, Estimation of the paleostress field from the 3-D orientation distribution of microcracks and their geothermal conditions in the Toki Granite, central Japan. Jour. Geol. Soc. Japan. 114, 321-335.

Keywords: Healed microcrack, Paleostress analysis, Median Tectonic Line, Ryoke granite

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SCG68-P08 Room:Convention Hall Time:May 20 13:45-15:15

Modeling of fold-and-thrust belt by analogue experiment and simulation considering erosion

NAKATSUKASA, Masashi[1*], YAMADA Yasuhiro[1]

[1]Kyoto University Graduate School of Engineering

Fold-and-thrust belt is modeled by sandbox experiment and distinct elemental method considering erosion. As a result of experiment, over burden stress variation by erosion makes an effect to the geological deformation. In the simulation we could observe that stress concentrates just before thrust occurs and stress is released by thrust's activity.

Keywords: structural deformation, fold-and-thrust belt, sandbox experiment, distinct element method, erosion, stress change