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

SCG061-01 Room:302 Time:May 25 16:30-16:45

Anomalous depth dependency of the stress field in the 2007 Noto Hanto, Japan, earthquake: Potential involvement of a dee

Aitaro Kato[1*], Shin'ichi Sakai[1], Takashi Iidaka[1], Takaya Iwasaki[1], Eiji Kurashimo[1], Toshihiro Igarashi[1], Naoshi Hirata[1], Toshihiko Kanazawa[1], The group for the joint aftershock observation of the 2007 Noto Hanto Earthquake[1]

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We have elucidated depth variations in the stress field associated with the 2007 Noto Hanto, Japan, earthquake by stress tensor inversion using high-quality aftershock data obtained by a dense seismic network. Aftershocks that occurred above 4 km in depth indicated a strike-slip stress regime. By contrast, aftershocks in deeper parts indicated a thrust faulting stress regime. This depth variation in the stress regime correlates well with that in the slip direction derived from a finite source model using geodetic data. Furthermore, the maximum principal stress (S1) axis was stably oriented approximately W20N down to the depth of the mainshock hypocenter, largely in agreement with the regional stress field, but, below that depth, the S1 axis had no definite orientation, indicating horizontally isotropic stress. One likely cause of these drastic changes in the stress regime with depth is the buoyant force of a fluid reservoir localized beneath the seismogenic zone.

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Comparison between the seismologically determined stress and the geologically determined slip direction along an active

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We compared the seismologically determined stress solution and the fault-slip data observed at the outcrops along the Atera fault, Central Japan, to understand relationship between the crustal stress and the slip directions of active faults. The seismologically determined stress solution can account for all of the fault-slip data obtained from the main fault plane, whereas that cannot account for all of the fault-slip data apart from the main fault plane. The Atera fault is a NW-SE trending active sinistral strike-slip fault at the eastern part of Gifu Prefecture with high deformation rate and is one of the best studied active faults in Japan.

The seismologically determined stress solution was calculated by a stress tensor inversion technique (Michael, 1984) using the focal mechanism solutions of 22 microearthquakes that occurred around the study area between October 2003 and October 2010. The focal mechanism solutions consists mainly of reveres-faulting type and we obtained the stress solution with the maximum principal stress S1 oriented horizontally NW-SE or WNW-ESE. Misfit angles between the slip direction and the shear stress direction predicted by the stress solution are less than 30^o for all focal mechanism solutions, so we regard the stress solution as the crustal stress in the study area.

The fault-slip data were obtained at five outcrops of the Atera fault which was already reported by previous studies. Four of the outcrops are within 5 m and the other is about 100 m away from the main fault plane of the Atera fault. We observed more than 100 slickenlines on fault planes and acquired 58 fault-slip data composed of fault orientation, slip orientation, and sense of slip. Quite a few fault planes strike NW-SE and dip to the northeast and show dextral and sinistral strike-slip. Few fault planes show reverse fault. Crosscutting relationship among fault planes was not found.

We calculated a misfit angle of each fault-slip data for the stress solution and found that only about 20% of fault-slip data have misfit angle less than 30^o for the seismologically determined stress solution. It should be noted that all fault-slip data obtained from the main fault plane (5 data) show a small misfit angle less than 30^o, whereas those obtained apart from the main fault plane (0.3-100 m from the main fault plane) have a wide range of misfit angles. This variability of misfit angles indicates that slickenlines in the fracture zone have been formed by several different stresses. Small-scale spatial variation of stress regime in the fracture zone of an active fault may account for the variability of misfit angles. The other possibility is that the slickenlines have not been formed by the present stress regime but the geological paleostress regimes due to the long active history of the Atera fault.

A part of this research project has been conducted as the regulatory supporting research funded by the Nuclear and Industrial Safety Agency (NISA), Ministry of Economy, Trade and Industry (METI), Japan. The seismograph stations used in the microearthquake analysis include permanent stations operated by NIED (Hi-net), JMA, ERI, Nagoya University, and DPRI.

Keywords: Atera fault, active fault, microearthquake, focal mechanism solution, stress tensor inversion, minor fault

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Multi anisotropy observations in the vicinity Chelungpu fault near Dakeng, Taiwan

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The 1999 Chi- Chi earthquake (Mw=7.6) take place in Taichung, Central Taiwan. The high rupture velocity and displacement record in northern part of Chelungpu fault. The total rupture length over 100 km and width large 35 km, the rupture propagated from south to north and the bending in the north end extend to East-West direction. The mainshock is pure thrust fault in the south and thrust with strike-slip type in the north. After the contentious drilling to 2 km depth, TCDP Hole-A collected various geophysical downhole measurements to determine the physical properties near the active fault. The Dipole Sonic logs (DSI) and Formation micro imagers (FMI) data are discussed, the velocity anisotropy amount and fast shear azimuth can be analyzed in DSI and the stress azimuth variation was displayed in image logs. The DSI result indicated the apparently anisotropy decreasing with the depth, the significant low anisotropy is occurred near the fault zone. Comparison with both stress indicating logs, shows that the most dislocation of azimuth in each log is close to the depth 1110 meters and consistence with the borehole breakout rotation. The rotation patterns are in agreement with each other cased by stress-induced anisotropy.

Keywords: DSI, Anisotropy, Stress roatation, Breakout, Chelungpu fault, FMI

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SCG061-04 Room:302 Time:May 25 17:15-17:30

Stress state estimate by geophysical logs in NanTroSEIZE drilling project site C0009

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To determine the fault mechanism and seismogenic zone in NanKai Trough, NanTroSEIZE investigated 1.6 km (mbsf) riser drilling in the central Kumano forearc basin to characterize the geophysical properties for future drilling through the megasthrusts. There were several downhole measurements run in this pilot drilling including image logs, caliper and comprehensive geophysical logs sets. The borehole breakout and lack of the drilling induced tensile fractures in this reprocessing image logging indicated the direction of the minimum horizontal compressive stress (Shmin), which show the consistent with the far-field stress direction. If the borehole breakout observation in the possible accretionary prism are representative the relationship with the rock strength and horizontal principal stresses, the different behaviors of borehole rock failure emphasize the variation of horizontal principal stress ratio. In this paper, we constrain the possible magnitude and orientation of horizontal principal stress. The stress induced shear wave anisotropy in Unit III and breakout azimuth in Unit IV are suggested that the direction of SHMAX in this well parallel to the direction of Philippine sea plate to Japan motion. Despite there is uncertainty of rock strength, the P-wave velocity profile shows the less variation with the depth represent the change of rock strength in the small level. The lack of breakout and tensile fractures in Unit III are attributed to the effective hoop stress acting on the borehole wall are less than the rock strength, which implied there are lower difference of horizontal principal stress. The higher differential horizontal principal stress in Unit IV caused the presence of breakout as we observed in the resistivity image logs.

Keywords: NanTroSEIZE, FMI, Boorehole breakout, Rock strength, Effective stress

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Fault formation and stress change in the frontal zone of an accretionary wedge: Insight from numerical simulation

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We studied a relation between a fault formation and a stress change in the frontal zone of an accretionary wedge using numerical simulation. We modeled a formation process of an accretionary wedge by using the Distinct-Element method. We observed the fault activities and measured dynamic stress state in the numerical model.

Frontal thrusts were formed in the sediments in front of the wedge, and the displacements of the active frontal thrusts were large. On the other hand, intermittent reactivations with small displacement of the existing faults were observed in the wedge, though the new faults were not formed in the inside of the wedge.

Relatively isotropic and vertical compressional stress state was observed in the sediment far from the toe of the wedge. However, as coming closer to the toe of the wedge, the stress state change into anisotropic, and high and horizontal compressional stress is observed in front of the wedge. After the sediments were incorporated into the wedge, the direction of the maximum compressional stress inclined to trench ward and the stress state was changed into isotropic. The compressional stress was recovered to the horizontal as the wedge growth, but the increase of principal stress ratios was still small.

The relation between fault activity and stress change is summarized based on these results. Frontal thrusts were formed by the dominant horizontal compressional stress, which is caused by the plate subduction, in front of the wedge. The activities of the frontal thrusts release the stress, and the stress state is changed into isotropic. The frontal thrust is not able to be active under this isotropic stress state, and new frontal thrust is formed within the sediments under the anisotropic stress state in front of the wedge. On the other hand, horizontal compressional stress is increased again by the stop of the fault activity in the inside of the wedge. The existing faults are reactivated in the increasing horizontal state and release the stress by their activities before a formation of a new fault. To form new faults (out-of-sequence thrusts) within the wedge, particular mechanisms are necessary that existing faults are to be inactive and that an anisotropic stress state is to be generated.

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Application of Compact Conical-Ended Borehole Overcoring Technique for Initial Stress Measurement of Discontinuous Rocks

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Keywords: Discontinuous Rocks, The Compact Conical-Ended Borehole Overcoring Technique, Initial Stress Measurement

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Heterogeneous stress analysis and Shmax trajectories around Shikoku

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Philippine Sea Plate is obliquely subducting beneath Shikoku. Shikoku is also close to backarc opening region toward west. Thus stress state in Shikoku is very important to understand dynamics of oblique subduction and/or backarc opening. To reveal stress field, we use focal mechanisms and stress inversion technique. We determined focal mechanisms using observations of our observatory and exchanged data among other institutes and universities since 1995. We obtained 1950 high accuracy focal mechanisms (depth lt 20 km). Stress inversions using these results are conducted for 29 divided regions. We use multiple inverse technique for the stress inversion (Yamaji, 2010). Number of stress solutions within subregions are adjusted to 2 or 3 using analyzed results. Obtained stress solutions shows 4 stress provinces(1) Shikoku, 2) near MTL, 3) Sanyo, 4) Sannin,) across arc. In contrast, along arc variation, extensional stress states appear in Iyonada, Takanawa, Bungo-channel, Western Shikoku in addition to widely distributed compressional stress state. This extensional stress shows N-S extension which is different from those of Terakawa and Matsu'ura (2010) (E-W extension). Trajectories of Shmax directions are drawn using obtained stress states based on Lund and Townend (2007). Obtained trajectory map is similar with that obtained from geological research (Tsukuda, 1992).

Keywords: Stress field, focal mechanism, Maximum horizontal compression, Shikoku

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Kinematics of the mylonite controlled by the stress regime

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The kinematics of mylonite is usually discussed based on the orientation of foliations, lineations, and microstructural asymmetric structures in structural geology. The relationship between the kinematics of the mylonite and the stress field has not been quantitatively evaluated previously. In this study, we examine the relationship within the mylonite developed along the Median Tectonic Line, in the eastern Kii peninsula in Japan.

The Geological Survey of Japan, AIST (GSJ, AIST) recently constructed an integrated groundwater observatory close to the MTL in the eastern Kii peninsula in Japan, and borehole core sample which penetrates the MTL was obtained during the construction. We used the fault slip data acquired in this core sample for the analysis.

The orientation of the foliations and lineations in the mylonite is gradually changed towards the MTL. Foliations dip to NNE or NE and the lineations plunge shallowly to east in the region apart from the MTL. Foliations dip to NNW and lineations plunge ENE and some of the lineations plunge steeply to the direction from NE to east in the vicinity of the MTL. These suggest that sigmoidal shaped foliations are developed within the mylonite along the MTL, and shear strain gradually increase toward the center of the shear zone.

The stress inversion based on the orientations of the foliations and lineations in the mylonite yield the stress field where the maximum stress axis is oriented WSW and stress ratio (=(S2-S3)/(S1-S3)) is approximately 0.2. The calculated orientations of the resolved shear stress for the sigmoidal shaped foliations are almost parallel to the observed orientation of lineation, i.e. the kinematics of the mylonite is controlled by the stress regime.

It has long been believed that the mylonite along the MTL shows the sinistral sense of shear. This is the case in weakly deformed mylonite. However the stress regime during the mylonitization resulted in the steeply plunging lineations in the vicinity of the MTL, suggesting the considerable component of reverse fault along the MTL during the mylonitizaion. The kinematics of the mylonite controlled by the stress regime may also influence the stress accumulation for the earthquake generation.

Keywords: Kinematics, Stress regime, mylonite, resolved shear stress, the Median Tectonic Line