Stress State around the Westernmost Ilain Plain of NE Taiwan and Its Implications

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Stress state is a key to understanding the dynamics of the solid Earth and also plays a vital role of manipulating plate tectonics, earthquake faulting, geological structures, and fracture conduit/barrier. Taiwan mountain belt is located at the conjunction of oblique convergence and subduction flip between the Eurasian and Philippine Sea Plates. The Ilan Plain of NE Taiwan contains high geothermal gradient (~60℃/km) due to the heat advection of rapid rock uplift and the backarc extension of the opening Okinawa Trough. It will be essential to recognize the spatial distribution of stress state around the westernmost Ilan Plain for exploring the geothermal energy and deciphering the interaction evolution between mountain building compression and backarc extension.
In-situ stress assessments from multi-scale observations such as regionally focal mechanisms, local paleostress, borehole-based methods and core-based methods, show the strike-slip stress regime with NNE-SSW compression in the westernmost Ilan Plain. Results of hydraulic fracturing tests indicate the Shmin gradient of 17.7MPa/km in 750-765m interval of the JY-1 drilling. Drilling-induced tensile fractures identified from the FMI of 363-2201m in HCL-1 deep drilling are only observed in the interval of 392-1233m within the slate formation. SHmax, Sv, and Shmin gradients deduced from DITFs are estimated as 25.6, 24.9 and 15.4MPa/km, respectively and SHmax is N-S orientation. Results of N-S compressive strike-slip stress regime suggested that the backarc extension has not strongly influenced the westernmost Ilan Plain yet. Based on the core observations, NNE-striking steep open-filling fractures post-date the south-dipping slaty cleavage and also attain high dilation tendency under in-situ stress state.
In-situ stress evaluations within the Cingshui geothermal area west of the Ilan Plain also show the strike-slip stress regime with NNE-compression. According to examination results on cores retrieved from the interval of 600-800m in the IC21 geothermal drilling, attitudes of NWW-striking closed fractures and NNE-striking open-filling fractures are consistent with the predicted attitudes of fluid barriers and conduits respectively. Based on Bingham statistics computed from the distribution of open-filling fractures, the paleo-stress orientations and ratio can be determined. Provided with rock mechanical data from experiments and fluid pressure from fluid inclusion analysis, and the simulation of appropriated differential stress below failure criteria, the complete parameters of paleo-stress state can be obtained. Bootstrap simulation can further afford the statistic constraints of paleo-stress state. Our results suggest that the development of open-filling fractures was at the depth of ~4.6km with NNE-compressive stress regime and fluid pressure of 54MPa and geothermal gradient was about 36-59℃/km, which is lower than the current geothermal gradient of 69℃/km.
Our results illustrate that although backarc extension has not intensely affected the westernmost Ilan Plain yet, the geothermal gradient of the Cingshui geothermal area is already begun to increase. These

establishments between in-situ stress and fluid conduits can explain the current results of geothermal exploration and deliver the important information for developments of the enhanced geothermal system in Taiwan. Moreover, outcomes of this study shed the lights on evaluating the interaction processes between of mountain building compression and backarc extension.

Keywords: Stress State, Enhanced Geothermal System, Ilan Plain, Taiwan

