Detection of shear heating on an out-of-sequence thrust using Raman CM geothermometry and constraints on the fault strength and total displacement by thermal modeling

*森 宏[1]、原 英俊[2]、中村 佳博[3]
*Hiroshi Mori[1], Hidetoshi Hara[2], Yoshihiro Nakamura[3]

1. 信州大学理学部、2. 産業技術総合研究所地質情報研究部門、3. 新潟大学大学院自然科学研究科
1. Faculty of Science, Shinshu University, 2. Institute of Geology and Geoinformation (Geological Survey of Japan), National Institute of Advanced Industrial Science and Technology, 3. Graduate School of Science and Technology, Niigata University

Out-of-sequence thrusts (OST) in subduction zones contribute to the thickening of accretionary prisms and some parts of them are explained as splay faults branched from plate boundaries. Making reliable estimations of the fault properties and displacement histories is therefore an important part of developing better understanding of such as generation of large earthquakes and tectonic evolutions in subduction zones. Mechanical work during fault movement is largely converted into heat energy and therefore quantification of shear heating recorded in rocks around on-land exhumed OST has potential to help in understanding the above estimations. Here we show approaches to recognize shear heating and to constrain fault strengths and total displacements from rocks around on-land OST using the Raman carbonaceous material (CM) geothermometry and thermal modeling.
This study focused on the Aki Tectonic Like (ATL)—which is an OST bounded between the Cretaceous and Tertiary sedimentary rocks of the Shimanto accretionary complex—in the Umaji area of eastern Shikoku, SW Japan. Results of estimated temperatures using the geothermometer show a regional temperature of ˜220–230 ºC. There is a significant rise in temperature to ˜270–280 ºC near the ATL on both hanging wall to the north and footwall to the south. The spatial association of the thermal anomalies with the fault implies shear heating. In contrast, the width of the thermal anomaly on the hanging wall side is ˜6 km while that on the footwall side is a few hundred meters, showing asymmetric distribution of the zones of shear heating between north and south of the ATL. One possible explanation for the asymmetric thermal structure is that the footwall part has been attenuated by post-heating faulting. To evaluate these results in terms of shear heating on the ATL, we compared the thermal structure of the hanging wall part—which is likely preserve original thermal anomaly—to the temperature distributions calculated using simple analytical solutions for one-dimensional conductive heat flow with a planer heat source. The results of the comparisons with a constraint on slip rate show that a coefficient of friction of greater than ˜0.4 and a total displacement of ˜25–50 km are required.

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