Active Faulting and Pore-Fluid Pressure in the Taiwan Thrust Belt

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Pore-fluid pressures significantly in excess of hydrostatic are thought to play an important role in the mechanics of overthrust faulting (Hubbert and Rubey, 1959). However in western Taiwan we argue, based upon a regional analysis of fluid pressures in 76 deep wells, that fluid pressures on the Pliocene Chinshui Shale detachment and ramp of the Chelungpu thrust system that ruptured the surface during 1999 Chi-Chi earthquake ($M_w = 7.6$) are within the hydrostatic regime and not overpressured. The fluid pressure data are obtained from in-situ borehole pressure measurements (formation tests), from densities of drilling muds, and from analysis of sonic logs using standard petroleum methods show fluid pressures in western Taiwan are stratigraphically controlled, as is typical of clastic sedimentary basins. The analysis provides constraints not only on present-day fluid pressure, but also pressures before uplift and erosion of growing structures which causes a large drop in overpressures. The top of the present overpressured zone is located at Miocene Nankang-Tsouho Formation in the north of Miao-Li, rises to the south to the Nanchuang and Kueichulin Formations in central Taiwan and only reaches the level of the Pliocene Chinshui Shale near Chia-Li (north of Tainan). Therefore the Chelungpu thrust sheet is everywhere in hydrostatic since this thrust runs along the Chinshui shale. This leads us to the conclusion that the static (ambient) pore-fluid overpressure plays no role in controlling fault friction of the Chelungpu thrust. The shallow detachment must be sliding under other mechanisms. Other shallow thrusts penetrated by drilling such as the Hsincheng thrust between Chingtsaohu and Paoshan anticlines and the Luchukeng thrust west of Yunghoshan anticline are also within hydrostatic regime. None of these thrust were ever overpressured as shown by the fossil top of overpressures which is based upon the deviation of porosity controlled shale velocities from the normal compaction trend shown by sonic log data using standard petroleum techniques that show the magnitude of uplift and erosion and the fossil and present pore-fluid pressures. The fossil top of the overpressured zone in several wells drilled through major thrusts and eroded anticlines is at a substantially higher (~1-2 km) stratigraphic level than the present top of fluid pressures, but never reaches the level of the Pliocene Chinshui Shale. It implies uplift and erosion of the active fold-and-thrust belt causes a major drop in fluid pressures in the formerly overpressured zone. Finally, a preliminary estimate of Hubbert-Rubey fluid pressure ratio needed to slide the Chelungpu thrust sheet (and also the Changhua thrust) using normal Byerlee's Law friction is about 0.8 (which is higher than any observed fluid pressures even within the deeper overpressured zone). Therefore the Hubbert and Rubey mechanism of static excess fluid pressure

does not appear to be important for major thrusts such as the Chelungpu thrust that slipped in the Chi-Chi earthquake. The many other proposed non-Hubbert-Rubey mechanisms of reduction of fault strength should be considered, including dynamical mechanisms, fluid-pressure transients and non Byerlee coefficients of friction.