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Perspectives of Taiwan Tectonics from TAIGER Project

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Taiwan is one of the youngest and most active orogenies in the world. It can be taken as a good "present" for us to use as the "key" to understand other older orogenies in China and around the world. Through the TAIGER project we have obtained a large amount of geophysical data. Being young and active the Taiwan orogen provides an environment for detailed studies of ongoing orogenic processes. Analyses of recently acquired subsurface data added important constraints to testing and exploring models regarding collision of plates, one of the key steps in building continents. The major subsurface structures we have mapped are significant ones that can be discussed in terms of tectonic understanding of Taiwan in particular but also have bearings on orogeny in general.

With regard to the current state of EUP subduction we confirm the presence of high velocity anomalies and their associated W-B earthquakes and therefore the active subduction in southern Taiwan south of ~22.7^{O}N. While the high velocity anomalies continue up to about 23.5^{O}N there are no known intermediate depth earthquakes in this section; the possibilities include quiescent subduction, i.e., involving ductile processes, or that the subduction has halted in this section. Further north, the high velocity anomalies are not as high as in the south and are disorganized. In any case, the subducting PSP would interfere with EUP subduction if the latter were extant. Furthermore the direction of the fast polarized S waves in the split-S is not consistent with subduction. Our current conclusion is that active subduction of EUP along the Manila Trench is still taking place in southern Taiwan but for the main collision section in central Taiwan and under northern Taiwan EUP has either stopped subduction because continental materials have jammed up against each other that are too light to subduct, or other processes such as eclogitization and delamination may have initiated in a different sort of subduction.

The implication of trend-parallel fast directions of splitted S-waves on the vertical extent of orogens has been a current topic in the last twenty years. Similar fast direction observations have been obtained for many major mountain ranges around the world, including Tienshan (Silver, 1996), South Island (Klosko et al. (1999), Zagros (Kaviani et al., 2009). The vertical coherence hypothesis proposed to explain this phenomenon needs to be tested. 3-D mapping of the source of the anisotropy is necessary but such research is just beginning.. The overall signature of a significant anisotropic presence limited to Taiwan however is clear. We observe that the delay times and directions of the fast S-wave at Lanhsu, offshore of SE Taiwan and Penghu, in the Taiwan Strait, are noticeably different from those on Taiwan. Recent observations of SKS splitting at 17 broadband stations deployed during the TAIGER project by Gao et al.

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(Qiusheng Li, personal communication, 2012) show further the relative small delay time and the widely varying orientation of the fast directions of S-waves onshore of SE China.

The rapid uplifting, the dramatic crustal thickening and the possible high temperature at mid-crustal depths point to the key role the Central Range plays in the orogeny as a whole. From the tomographic images the formation of the Central Range involves exhumation of mid-crustal rocks as well as down drafting. The generally quiescent portion of the Central Range demonstrates that ductile deformation dominates. On the other hand, the thickness of the crust places the rocks in a range of pressure and temperature such that important petrological changes may occur. At a depth below 40 km or more amphibolite, when provided with enough water may become ecologite with 6% or so density change (Leach, 2001). The consequences include the promotion of exchanges between the crust and mantle and eventually delamination, the parting of the high velocity materials in the upper mantle from the bottom of the crust.

Finally, the newly acquired TAIGER data convey further the three dimensional nature of the Taiwan orogen, in terms of the change in velocity structures, the coupling of the plate and developing the orogen along the structural trend and the way mountains are built. The transition from subduction in the south to PSP/EUR lithosphere-against-lithosphere collision in central Taiwan and to the collision of a subducting PSP with EUR in the north cover a range of mechanisms and processes that begin to become clear. In the subduction section the arc are still separated from the continental shelf by over a hundred kilometers; the mountains south of ~22.7^{O}N have been built over the subduction zone without the arc, or the continental shelf, in contact. In central Taiwan the Hsueshan Range was built out of continental shelf sediments and it stops roughly where the continental shelf is located. The Coastal Range undergoes a major change where the PSP boundary runs into Taiwan; the southern part is rising fairly fast but the northern part is subsiding. The northern Taiwan mountain building is with a “diving” collision – PSP subducts while collides, such that northern Taiwan orogeny is achieved through compression at ever increasing depth and it stops when PSP dives under the lithosphere; the PSP creates a bight in northern Taiwan where the trend of the local structures all turn eastward.

Although Taiwan is a relatively small myriad orogenic processes are in operation. Further detailed studies will allow us to test old and new hypotheses and learn much more about orogeny.