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Redefining the Taiwan orogeny

Taiwan is located on the Circum-Pacific Seismic Zone; therefore it is disturbed by numerous daily earthquakes due to the convergence and collision between the Eurasian Plate (EP) and the Philippine Sea Plate (PSP). The PSP is in southeastern Taiwan and moves northwest toward the EP at a velocity of 82 mm/year. The EP subducts underneath the PSP in the Huatung Valley, which is located in southeastern Taiwan, and extends south to the Manila Trench. The collision between the two plates forces the island of Taiwan to rise and grow taller via a geologic process known as orogeny.

There exists two different theories for the formation of the Taiwan orogeny. One theory, called the thin-skinned model, states that only the upper crust is compressed and deformed, while there is no interaction with the EP below the PSP. The other theory is called the thick-skinned model, which asserts that both the EP and the PSP take part in the orogeny and are deformed by the collision.

There has been much debate about the two theories. Although evidence supporting each theory has been put forth, both still lack decisive verification. However, this past August, a team from the Department of Geoscience and the Institute of Oceanography at the National Taiwan University (NTU) and the Institute of Earth Sciences at Academia Sinica

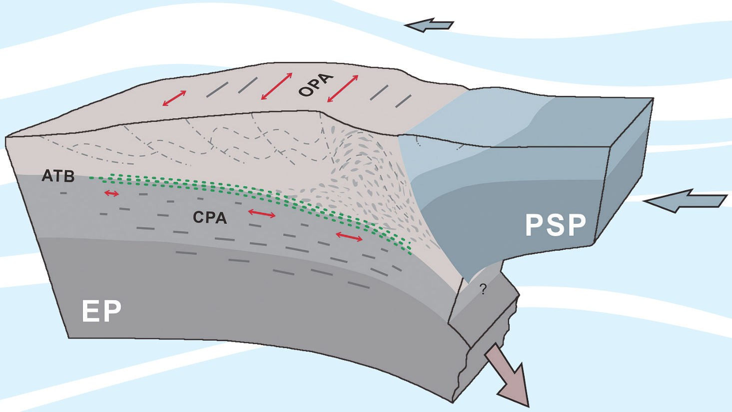

Illustration of the coupled layered deformation zones in the Taiwan orogen. The compressional tectonics and the subduction-dominated deformation are characterized by the orogen-parallel anisotropy and the convergence-parallel anisotropy, respectively. Red double-headed arrows highlight the rapid movement of these two sets of anisotropy. The anisotropy transition boundary (green dots) separates the two deformation regimes and couples the upper crust of the orogen with the subduction zone.

published a paper in Science that explained this long-standing mystery using new technology and observational data.

This paper utilized ambient seismic noises from broadband stations to derive empirical Green's functions that were used to construct a high-resolution three-dimensional model of the seismic anisotropy of Taiwan. From these images, they found that deformation occurred in both the upper and lower plates, similar to the traditional thick-skinned theory. However, the results also revealed that the deformation mechanisms were completely different in the upper and lower crust, similar to the layered phenomenon described by the thin-skinned model. Therefore, neither of the two traditional theories alone could adequately explain the data.

Instead, the research provided a new orogenic model for Taiwan in which the upper crust is dominated by collision-related compressional deformation, whereas the lower crust experiences convergence-parallel shear deformation. This lower crustal shearing was identified as being driven by the continuous sinking of the Eurasian mantle lithosphere when the surface of the subducted plate is coupled with the orogen (Figure 1).

This paper helped to resolve an important mystery in the geological history of Taiwan. Both the upper and lower crust participate in orogeny, although their deformation mechanisms are completely different. The coupled layered deformation mechanism proposed in this research provides an alternative perspective on mountain building and clearly defines the role of subduction in the formation of the Taiwan mountain belt.

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Concealed waves under the sea

The life cycle of the world's most powerful internal waves

There are two types of gravity waves: surface waves at sea level, which can be observed and enjoyed at the beach, and internal waves, which are hidden beneath the surface. Gravity waves are generated at the interface between two media or because of the different densities of two fluids. The interface between the air and the water gives rise to surface waves. Similarly, internal waves are caused by density stratification due to salinity and/or temperature changes of water. The largest internal waves in the world are located in the South China Sea. However, there has been a lack of data for this region due to the challenges related to underwater research. Nevertheless, the energy pattern of internal gravity waves is a key factor for numerical climate models, emphasizing the need for more detailed studies.

Since 2000 and in collaboration with scientists from the United States, a group from the Institute of Oceanography at National Taiwan University has led a large international project targeting data collection in the South China Sea. Hundreds of researchers, technicians and students have participated in this project, which is supported by the Taiwan Ministry of Science and Technology and the U.S. Office of Naval Research. In May 2015, the achievements of this project were published in Nature, in a paper which was co-authored by 28 researchers from the U.S., Taiwan, Canada, and South Korea. With the help