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Subsurface soft sediments deformation system: a case study in Qiongdongnan Basin, northern South China Sea

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ABSTRACT
Soft sediment deformations are prevailing in the deep-water area worldwide. “Subsurface soft sediments deformation system” is a collective term used to describe a series of features that are ductile deformations and formed by different but interconnected mechanisms in shallow burial stage. The soft sediment deformations are usually related with high pore pressure. The increase of pore pressure is the main factor that makes sediment behavior change from a solid nature to a liquid one. Here, the sediment deformations which we refer to are polygonal fault (in situ), mass movement (detached) and sinks (in situ), which formed mainly in unconsolidated soft sediments above the upper Miocene in Qiongdongnan Basin, the northern South China Sea. The 3D seismic data acquired from the study area, tied to regional grids of 2D seismic reflection data, provides new insights into the forming processes of the subsurface soft sediments deformation.

Fine-grained hemipelagic-pelagic sediments deposited in layer on the slope and flat area until Pleistocene. The sedimentation rate is very high in the northern South China Sea in Neocene, and the linear sedimentation rates (LSRs) is 300-1100 m/m.y for the last 1m.y. The pore fluid is unable to de-water adequately because of the rapid sediments loading and lower permeability. Under these conditions, the lower successions first achieved overpressure, and then syneresis occurred and formed polygonal faults. The forming processes of polygonal faults accompany with the expulsion of fluid in the host rock. The troughs also indicate the polygonal faults are probably as fluid conduit. The fluid expelled from the host rock of or migrated along polygonal faults will accumulated on the bottom of Unit II, especially, in the incised valleys. Moreover, the local fluid restricted within Unit II, the water content in the bottom of Unit II will be higher and formed excess pore pressure. Thus, these will cause the formation of soft layer in the bottom of Unit II. This also can cause partial liquefaction which has been observed in nature and experimentally.

The slope plays an important role on the mass movement. The sediments do not rotate on the flat area. However, once the soft layer has formed, even gentle slope can trigger the mass movement. The high water content and overpressure probably cause sediments liquefaction and wholly ductile deformation when sediments remobilized. So the head scarps and extensional ridges and blocks are not existent in the headwall domain. The liquefied sediments move down slope and re-accumulated there, and the up slope became thin. In the toe domain of the mass movement, static block inhibits the mass movement, and sub-parallel beaklike reflections and compressive folds occurred to respond to the compression. The fluctuation of Unit II triggered the weak zone (slip surface) in Unit III. And fluid escaped along these weak zones (slip surface) to the sea floor. The loss of water will cause subsidence and differential compaction of Unit III. Then the sinks formed on the sea floor. Most of the fluid will escape to the sea water, and this will result the decrease of pore pressure in the deformation system. Then the deformation system will stop. Possibly, the deformation system will re-active when the pressure re-accumulates.

The analysis of the subsurface soft sediment deformation system can use in other area (especially deep water area) worldwide to explore the internal relationship among the different deformations.