Seismic expressions of the Yongle Atoll and the Sansha Yongle Blue Hole in the Xisha Islands, Northwestern South China Sea

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Sansha Yongle Blue Hole is an oceanic blue hole and is located at the northeastern edge of the Yongle Atoll, in the Xisha Islands of the northwestern South China Sea. The 301.19 m deep makes it to be the deepest known blue hole in the world. Despite the 3-D morphology, hydrochemical properties and chemocline of the blue hole have been comprehensive investigated, its karst formation process is still enigmatic. This study presented new acquired multi-channel seismic data across the Yongle Atoll and seismic data across the Sansha Yongle Blue Hole to describe the seismic reflection characteristics of the carbonate platform and the blue hole in extensive detail. Combined with the scientific wells drilled on the atoll, our results show that carbonate sequences including Lower Miocene, Middle Miocene, Upper Miocene, Pliocene and Quaternary developed on the platform. The magmatically intrusive activity and related magmatic hydrothermal fluid flows have been very active since 5.5 Ma around/on the Yongle Atoll, and may remain active on both slopes and the carbonate platform of the Yongle Atoll at present. Seismic profiles also show that the blue hole is characterized by chaotic seismic reflections which are easily distinguished from surrounding carbonate rocks with sub-parallel, continuous, low to medium amplitude, and low to medium seismic reflections. It seems that the depth of the blue hole is deeper than that measured according to the seismic images. The results of δ¹⁸O from scientific wells show that the phreatic extent in the Xisha Islands is from 14.75 – 38.89 m to 152.06 – 183.29 m. Therefore, different from other classic karstological blue holes formed by the phreatic dissolution processes, a hydrothermal – phreatic model with magmatic hydrothermal pipes and collapse of deep seated phreatic dissolution voids was proposed to describe the formation of the Sansha Yongle Blue Hole.