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Cryogenian solar activities recorded in the non-glacial Datangpo Formation in South China

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Variations in solar radiation enforce climate change at decadal to centennial time scales. However, documented solar-induced climate cycles in the geological record are rare due to the general lack of identifiable solar climatic signals in the deep-time sediments. Here we report our new findings of solar-activity cycles recorded in the Cryogenian Datangpo Formation, South China.

The Datangpo Formation in the deep-water setting of the Nanhua basin preserves a continuous record of the Cryogenian non-glacial interval, characterized by laminated siltstone in the upper part and mudstone in the lower part. We investigated the millimeter- and sub-millimeter-scale rhythmites from a drillcore obtained from northeastern Guizhou Province, which was paleogeographically located in a slope environment of the Nanhua basin. The laminations are expressed as alternating light and dark laminae. The light laminae are dominated by quartz, albite and mica, while the dark laminae consist of mainly clay minerals. We consider that warm and wet periods had more intense weathering and more clay mineral input, while cold and dry periods had less clay but more silicate mineral input into the basin. Thus, the laminations may record signal of paleoclimate changes.

We polished the core and photographed the polished surface with a high-pixel camera. Grey-scale data were obtained using ImageJ at an average resolution of 0.08 mm. Continuous X-ray fluorescence (XRF) scanning was conducted using ITRAX core scanner, with a resolution of 0.25 mm. The grey-scale data and element concentrations (e.g., Si, Al, Mn/Fe, Rb/K...) are used for cycle analyses.

Power spectrum and wavelet transform analyses of the grey-scale and element concentration data reveal a hierarchy of sedimentary cycle bands of 0.3–0.5 mm, 0.7–1.1 mm and 3–4 mm, the ratios of which match well with the ratios of the 11-yr Schwabe sunspot cycle, 22-yr solar Hale cycle and 88-yr Wolf-Gleissberg cycle, respectively. These cycle bands are interpreted as recording solar-induced climate cycles that allow for estimation of the average sedimentary rate at $\sim$3.0 cm/kyr, which is consistent with sedimentary rate derived from the long-term cyclostratigraphic analyses of the same drillcore samples. The presence of solar-induced climate cycles identical to those of the Holocene from the Cryogrnian non-glacial interlude suggests that the solar-activity periods did not change significantly during the past 660 million years.