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Giant submarine collapse of a carbonate platform at the Cenomanian-Turonian transition: the Ayabacas Formation of southern Peru

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We have performed a thorough study of the Ayabacas Formation, an impressively disturbed, mainly carbonate unit that crops out irregularly over more than 160,000 km^2, mainly in the Altiplano and Eastern Cordillera of southern Peru. Its thickness increases from 0 m in the NE to $>$500 m in the W and SW. This extraordinary unit results from the giant submarine collapse of the major part of a carbonate platform that developed mainly during the late Cenomanian transgression. The collapse occurred slightly later (given that the limestones were only partially lithified when they slid), most likely during the sea-level fall of the post-OAE2, latest Cenomanian – earliest Turonian, major marine regression. The collapse is post-dated by Turonian-Santonian red beds.

The Ayabacas Formation displays 6 main different facies or styles of deformation, which reflect a downslope, WSW-ward increase in fragmentation of the Cenomanian carbonate platform. Facies in parts of the collapse are very similar to 3D seismic images of recent submarine landslides. In the ENE-most area, i.e. the most proximal part of the basin, the thin ($\sim$20 m) carbonate platform was not destabilized (zone 0). In zones 1 to 3, normal faults have shaped the pre-Ayabacas substratum into tilted blocks and mixed partially lithified limestones with the underlying unlithified red mudstones and fine sandstones, resulting in a chaos of soft-folded limestone floating in a matrix of mudstones and sedimentary breccias; isolated and rare lithified large blocks of older units may also be found in the slide deposits. Westwards, in zones 4 and 5, limestones were brecciated by hydraulic fracturing and often slid as “sedimentary thrust and fold systems”, as described in the literature. In zone 6, the lower part of the unit was not

destabilized whereas its upper part is formed by piled-up slides, suggesting that this zone mostly behaved as an accumulation area, in contrast with zones 1-5 characterized by slide origination and/or transport.

The WNW-wards change in slide facies is in agreement with the basin slope as reconstructed from depositional facies and thicknesses. Thicknesses of the initial limestone deposits and of the displaced mass increase WSW-wards. Zones 4 to 6 display recurrent slide events, whereas such distinctions cannot be made in the chaotic mass characteristic of zones 1 to 3. Deformation in zone 5 and 6 characteristically includes large asymmetrical to recumbent folds, whose styles are very distinct from the regional Andean tectonic deformation.

The giant collapse documented by the Ayabacas Formation provides a prime example that large-scale submarine mass movements, similar to those known in current margins, have occurred in the Cretaceous, namely near the Cenomanian-Turonian transition. This particular time in Earth's history was marked by a significant drop in sea-level, during which the collapse apparently occurred. This coincidence contributes to the debate over whether rapid sea-level drops have had a role in triggering recent collapses.