4.2. Deciphering the recurrence of marine sedimentary processes

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Sedimentary processes have been part of the history of our oceans throughout geologic time. These processes have been the same for several million years, forming a wide but limited range of events that are repeated at frequencies depending on the dominant geological framework. The recurrence of sedimentary processes depends on whether they are tied to steady conditions, convulsive geologic events, extraordinarily energetic events of regional influence (e.g. explosive volcanic eruptions, giant mass failures, catastrophic floods, major earthquakes and giant tsunamis), cyclic sea-level and climate changes or tectonic pulses. Here, we present the way that geologists approach cyclicity and recurrence and we formulate some research questions.

Why do we do it?

The recurrence of marine sedimentary processes (e.g. mass-flows, turbidity flows, bottom currents flows and faults) must be deciphered in order to understand the geological evolution of the continental margins and basins and to identify the potential geological hazards that these processes may represent. To tackle this problem, marine geologists have to decode the sedimentary records preserved in the seafloor and in the

![Short-term recurrence of sedimentary processes](image)

**Figure 1.** A, sediment cores showing three types of sediment (contourites, turbidites and debrites; modified from Alonso et al. 2016). B, sediment core showing the high recurrence of palaeo-bottom current changes during the last 25 kyr.
physiographic domains of continental margins (shelf, slope and rise) and basins.

How do we do it?

Knowledge of the sedimentary record is mainly achieved by studying seismic profiles and sediment cores (Figures 1, 2). Both are essential tools for defining the stratigraphic and sedimentary framework, determining which deposits are older, how they are laterally related to other deposits and how their characteristics (e.g. composition) change. In order to decipher the recurrence of sedimentary processes, it is necessary to know the chronology of the geologic events. There are two approaches for doing so: direct and indirect. The direct method consists in quantifying the age of sediment samples through accelerator mass spectrometry radiocarbon ages and oxygen isotope records (Figure 1B). The indirect method determines the age of sedimentary deposits recorded on seismic profiles by identifying and correlating seismic boundaries (horizons) with the calibrated ages of sediment cores. Other invasive tools (sampling for sedimentology, chemistry and mineralogy) and non-invasive tools (e.g. multi-sensor core logger, X-ray fluorescence scanning, X-ray images, X-ray computed tomography and photographs) working at different resolutions are also important for interpreting sedimentary processes and calculating their recurrence.

The use of sedimentary records, seismic profiles and sediment cores, provides information at two timescales: thousands to hundreds of years (Figure 1B) and millions of years (Figure 2).

What is the recurrence of sedimentary processes on the Iberian Margins?

The frequency of triggering of mass-flow events in the Alboran Sea has been estimated to range from medium (one event every ~40 kyr) to low (one event every ~300 kyr). A medium frequency of mass-flow events predominates throughout the Quaternary (2.6 Ma to present); Figure 1; Alonso et al. 2014). This recurrence is closely linked to tectonic/earthquake pulses defining the evolution of the eastern Alboran Sea. The sediment source of turbidite flows is usually linked to sediment transport from rivers to submarine canyons during sea-level falls or from the continental shelf to canyons during sea-level rises and highstands. The frequency of events is therefore highly variable, sometimes with patterns driven by sea-level cycles of 400, 200 or 100 kyr. In another geological context, the deep oceanic environment of the Galicia Bank, where no influence of river discharge occurs, moderate recurrence of turbidity flows has been described: up to one event every 3 kyr (Alonso et al. 2008).
Other geological processes linked to oceanographic dynamics such as bottom currents are subject to the variability and rates of water mass changes. High and moderate frequency of palaeo–bottom current changes have been detected in the western Mediterranean (one event every 1.9, 2.3, 4.0 and 6.2 kyr; Alonso et al. 2021). These events are potentially linked to both oceanic and solar forcing mechanisms, which impinge on the deposition of contouritic deposits where these changes are recorded (Figure 1B).

Earth and the oceans are in constant evolution, and geologic time involves an enormous number of years from a human perspective. Even considering the huge range of time that could be involved in the construction of a particular sedimentary system, the emergence of instant geological events, even on a human scale, is not only possible but has a probability that should not be neglected.

References

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