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Event Stratigraphy

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Summary

The 'Event Stratigraphy' was initially proposed for recognition and stratigraphic correlation of the effects of significant and episodic physical and biological events record in wide regions. Traditionally, there is a dispute between the scope of 'Event Stratigraphy' in relation to Cyclostratigraphy, once that events before considered episodic, has become more and more predictable changes as part of models developed by researchers in different fields of knowledge, especially in geology. Despite of this dispute, rare and unique events are still among the changes to be accurately determined and analyzed by 'Event Stratigraphy'. These events can be found in the limits of systems and stages of the Global Boundary Stratotype Section and Point (GSSP) of the International Commission of Stratigraphy (ICS) and corresponding to changes used to establish the boundaries between any two specific stages, be their biological (FADs of taxa) or geological (isotope changes, magnetic reversals, geochemical anomalies) origin, that can be extended and traced in wide regions. Also, one of the goals of 'Event Stratigraphy' is to decipher the nature, causes and extension of such deviations or anomalies marked in the geological record.

Keywords: synchronous horizons, correlation events, stratigraphic unit's boundaries, chronostratigraphic scale

'Event Stratigraphy' was a term initially proposed by Arger (1973) for the recognition, analysis, and correlation of the effects of significant physical events (e.g. marine transgressions, volcanic eruptions, geomagnetic polarity reversals, dramatic climatic changes), or biological events (e.g. extinctions, radiations), in the stratigraphic record of widespread areas. In fact, he argued that by correlating these effects evidenced in the sedimentary record, it will be possible to define truthfully synchronous horizons, thus leading to higher resolution and a more accurate chronostratigraphic scale (*in* Allaby & Allaby, 2008). Also, Seilacher (1984) suggested the term 'Event Stratinomy' for the study of events at the level of individual beds.

Since the beginning of the establishment of the concept of Event Stratigraphy, there were issues regarding the exact definition of what events are. Seilacher (*in* Einsele *et al.*, 1991) defined 'Events' as unpredictable, sudden, and therefore often catastrophic changes, such as, storms, floods, earthquakes, volcanic eruptions, mass movements, etc. Already for Whittaker *et al*. (1991), 'Events' are short-lived occurrences that have left some trace in the geological record, and which therefore may be used as a means of correlation. Because of this, International Subcommission on Stratigraphic Classification (ISSC) affirmed that the Event Stratigraphy deals with the identification and application of beds in the stratigraphic records which were caused by sudden events (Hilgen *et al*., 2002). Currently, Event Stratigraphy generally comprises the study of stratigraphical traces of relatively short-lived events compared to those normally observed on a geological time-scale.

Another issue to be clarified was the differentiation between 'Events' and 'Cycles', which is at the heart of the distinction between Event Stratigraphy and Cyclostratigraphy. 'Cycles' are understood to be relatively predictable and gradual changes which occur with a certain periodicity known (Seilacher *in* Einsele *et al*., 1991). Consequently, there is no strong link between Cyclostratigraphy and Event Stratigraphy because events are episodic rather than periodical in nature as cycles are (Hilgen *et al*., 2002). However, researchers have been trying to find out over time periodicities in such events or disasters, in order to make them more predictable. Afterward, even the most apparently unpredictable events, such as large meteorite impacts, volcanic eruptions or earthquakes, could occur within certain periodicities (Seilacher *in* Einsele *et al*., 1991). This means that the individual event-stratigraphic units may occur in clusters which are related to cyclic processes (Hilgen *et al*., 2002).

Another discipline originated at the same time, the Sequence Stratigraphy, pioneered by Vail *et al.* (1977), explains the complex geometries that sediments acquire as they fill *accommodation* in response to changes in rates of sedimentation, tectonic movements and sea-level changes. In this case, sedimentary cycles, named as parasequences, and episodic events, e.g. significant sea level falls or rises - marked by erosive or maximum flood surfaces, were embedded within a logical framework that has given meaning to these phenomena, making them predictable. This is just to show how events and cycles have been used in other methods of stratigraphic interpretation.

In fact, it is important to note is that events before considered episodic, has become more and more predictable changes as part of models developed by researchers in different fields of knowledge, especially in geology. Maybe that is why the Event Stratigraphy has not become a popular subarea in geologists or methodology usually applied. However, in recent decades, Event Stratigraphy has found great application in the determination and correlation to the Quaternary glacial episodes and some time intervals during the geologic history. The high-resolution oxygen isotope profile record from the Greenland ice-cores was used by Björck *et al*. (1998) as a basis for divide the Latest Pleistocene – Holocene interval into a series of datable 'isotopic events'. The authors claimed that the scheme is an 'Event Stratigraphy'. As such, boundaries between the events were not specifically designated, but problems of time-transgression that have arisen in applications of the terrestrial chronostratigraphy (radiocarbon dating) were no longer encountered. On the other hand, the succession of major climatic events recorded in ice-cores allowed an extensive correlation with sediment-based data based on different environmental proxies (fossil insects; stable isotope profiles; lacustrine sediments; laminated marine sediments; marine mollusks). Currently, the Antarctic isotope record is used in the Global Chronostratigraphical Correlation Table for the Last 2.7 million years (Cohen & Gibbard, 2010). Nevertheless, these climatic events have been tuned into distinct cycles, e.g. millennial-scale cycles or Heinrich events, and Milankovitch orbital cycles, and because of this considered as subject of the 'Cyclostratigraphy' (Weedon, 2003).

Despite of this dispute between the limits of 'Event Stratigraphy' and 'Cyclostratigraphy', rare and unique events are still among the changes to be accurately determined and analyzed by 'Event Stratigraphy'. These events can be found in the limits of systems and stages of the Global Boundary Stratotype Section and Point (GSSP) of the International Commission of Stratigraphy (ICS). Changes used to establish the boundaries between any two specific stages, be their biological (FADs of taxa) or geological (isotope changes, magnetic reversals, geochemical anomalies) origin, episodic events are ones that can be extended and traced in wide regions. Because of this, these changes are referred to as "Correlation Events" (International Commission of Stratigraphy, 2013), and serve as the standards for definition and recognition of a stratigraphic unit's boundaries beyond the type areas. One best example is the biggest mass extinction around the Permian-Triassic boundary which has become the most intensively studied biological event in the Phanerozoic. During last decades, quite a few distinct simultaneous events, including a globally recognized sharp negative shift of $\delta^{13}C$, a set of volcanic ash beds related to Siberian Traps and the sudden disappearance of fossils groups (Shen *et al*., 2011), can be served as multiple distinct markers for realizing precise synchronous correlation around the Permian-Triassic boundary interval. Such kind of event markers is extremely important for high-resolution correlation among different continents which are usually biased by using the first occurrences of different fossils due to the common incompleteness of fossil records. The establishment of these unit's boundaries is the procedure that most closely and applies the concepts and precepts laid down by the 'Event Stratigraphy' and thus where it is most used by geologists today.

Note that Event Stratigraphy also aims to explain the nature, causes and extension of these unique and episodic events. From this perspective we can realize how drastic the changes might have been that ravaged the Earth's surface over time. These findings serve as a warning to humans on the catastrophic natural phenomena and its disastrous consequences, especially for life on the planet as a whole. Knowing and understanding these can be critical in the future to prepare for such sporadic changes when they occur.

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