

A BRIEF REFLECTION ON THE POSSIBLE CAUSES OF THE CRETACEOUS/TERTIARY BOUNDARY BIOLOGICAL CRISIS

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RESUMEN

Con el fin de explicar las posibles causas que dieron lugar a la extinción masiva del límite Cretácico/Terciario se han propuesto diferentes hipótesis a lo largo de la última década. En el presente trabajo se propone la idea de que la crisis biológica pudo ser ocasionada por varios de los factores hasta ahora citados, actuando de una manera simultánea o durante un corto período de tiempo.

ABSTRACT

In order to determine the possible causes that originated the K/T boundary massive extinction different hypothesis have been proposed, particularly during the last decade. The present paper points out the idea of various known processes acting simultaneously or over a short period of time as responsible for this biological crisis.

LABURPENA

Kretaziko/Tertziario limitean gertatu zen suntsipen masiboaren zergatiak azaltzeko asmoz, zenbait hipotesi ezberdin planteatu dira azken hamarkadan zehar. Lan honetan azaltzen den ideiak zera adierazten du: Krisi biologikoaren sortzailea faktore isolatu eta bakarra izan beharrean, agian, orain arte aipatuak izan diren faktore batzuek izan daitezkeela, batera edo denbora-tarte labur batetan eraginez.

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INTRODUCTION

In this work a brief theoretical reflection on the so far proposed causes for the Cretaceous/Tertiary (K/T) boundary biological crisis is presented. Furthermore the idea of a simultaneous performance of some of these causes (at a geological time scale) as responsible of the massive extinction detected at this time of the Earth history is introduced.

The disappearance of species throughout time can be understood in different ways. Phyletic extinction seems to be a natural and common fact during life history on Earth. On the contrary, there are some other types of extinctions caused by interspecific competition, inadaptation to very changing environmental conditions, catastrophic processes, etc. These are much easily detectable on the geological record. The most interesting to scientists are the so-called massive extinctions characterised by the loss of more than half of the living species on the planet during a very short geological time interval (1-3.5 million years).

Among the numerous massive extinctions detected throughout the Phanerozoic Eon, the best known is that located on the K/T boundary, 66.4 million years ago (BERGGREN et al. 1985), with a great incidence on very diverse groups (planktonic foraminifera, calcareous nannoplankton, ammonites, dinosaurs, etc.). In order to explain this biological crisis many different causes have been invoked, some of them simply bizarre, others more reasoned scientifically and several contradictory. The theories enjoying more credibility until the last decade were those referred to transgressive/regressive cycles and to climatic variations. However, since 1980 the polemic arises when the hypothesis of a meteorite impact is suggested (ALVAREZ et al. 1980). Due to the participation in this discussion of an increasing number of researchers from different fields of science, new ideas have been presented and the amount of gathered information is so great that everybody finds evidences to justify his own theory. The polemic has reached such a point that the same arguments have been used to corroborate different hypothesis.

Recent observations carried out on new K/T boundary sections of the Basque Country (Northern Iberian Peninsula) encourage us to introduce a initial reflection on the possible causes responsible for the extinctions that took place at the end of the Mesozoic.

GENERAL DISCUSSION

As it is well known, at present the question is expressed, in general terms, between those authors invoking external or extraterrestrial causes (HUT et al. 1987, SMIT 1990) and those who reclaim internal or endogenetic causes (OFFICER & DRAKE 1985, HALLAM 1987) in order to explain this crisis. The dispute increases trying to clarify if the extinction was gradual (SEPKOSKY 1989), steepwise type (OFFICER et al. 1987) or catastrophic (HSÜ et al. 1982). From the above mentioned causes those having more credibility are: a meteorite impact (SMIT & HERTOGEN 1980, ALVAREZ 1986), intense global vulcanism (COURTILLOT et al. 1986, CAR-

TER et al. 1990) and those generating periodic extinctions such as a comet rain (RAUP & SEPKOSKY 1984, MULLER 1986) or processes internal to the biosphere (MCKINNEY 1989). The meteorite hypothesis has been recently supported thanks to the data on the geographical location of the actual impact site presented by SMIT (1991) and SIGURDSSON et al. (1991). On the whole, the different hypothesis suggested explain satisfactorily what happened to one or more groups of organisms but they do not allow to understand what occurred to the rest. In other words, no single idea can explain correctly all the different particular extinctions detected more or less simultaneously in diverse environments.

Within this controversy it is outstanding the fact that when an author, equipe or scientific school proposes a new hypothesis about the processes responsible for the K/T boundary crisis, normally all their future work is going to be directed to support only their own theory and to invalidate those from other scientists. On the other side, most of the new researchers joining the debate seem to be unconsciously dragged into fitting their results in one of the dominant theories at that time. In order to find a coherent explanation to this crisis it should be necessary to focus the problem without any previous conception, trying to take advantage of the increasing published material thanks to the growing number of continuous stratigraphic sections of this boundary known everyday. The Basque Country represents one of the most interesting areas in the world for the study of the K/T massive extinction in marine environments. Here it can be found the Bidart (Biarritz), Hendaia, Zumaia, Sopelana and Monte Urko (Eibar) sections, all of them very well known in the literature. Lately several different sections even more interesting and also deposited in deep marine environments have been discovered (Figure 1).

Fifteen new sections are being studied by one of the authors (E.A.) as part of her PhD Thesis. The results obtained will be published soon as specific research papers. Four of them recently analysed exhibit a K/T boundary sequence much more complete than the classical sections in the area. From these, a new section found in the vicinity of the well known Sopelana section (LAMOLDA et al. 1983; ORUE-ETXEBARRIA 1985; ROCCHIA et al. 1988; MARY et al., en prensa) shows a much more complete final Maastrichtian containing also a 7 cms clay layer (P_0 zone) (Figure 2). Within this clay three different levels showing particular colours and a disposition similar to that found in Stevns Klint, Denmark (ELLIOT et al. 1990) appear. The falloured lamina with a high content in extraterrestrial component is not found at the bottom, as mentioned in other works (SMIT & ROMEIN 1985), but it appears in the intermediate yellowish level, above a clear-grey level and below a dark-brown one. This particular disposition can also be observed in the other three new sections above mentioned. The Stevns Klint clay, similar to this new Sopelana section, shows a high content in Mg-smectite, that it has been interpreted as a volcanic ash alteration. As a consequence the lower level within the clay layer in Sopelana would be considered as the product of volcanic activity, the intermediate level would include components linked to the extraterrestrial meteorite impact, where-

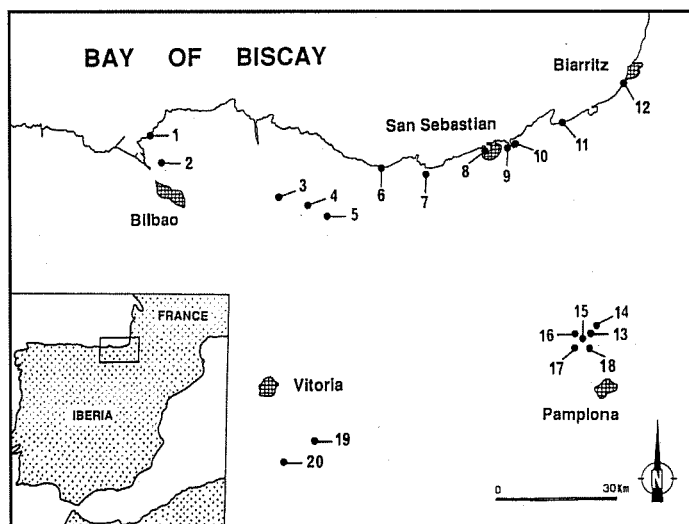


Figure 1.- Geographical location of some K/T boundary sections in marine facies from the Basque Country. Deep-marine facies: 1. Sopelana (I and III); 2. Leioa; 3. Urretxua; 4. Trabakua; 5. Monte Urko; 6. Zumaia; 7. Zarautz; 8. San Sebastian; 9. Pasajes; 10. Lezo; 11. Hendaia; 12. Bidart (Biarritz); 13. Eguaras; 14. Gascue; 15. Beorburu; 16. Musquiz; 17. Osinaga; 18. Markalain. Shallow-marine facies: 19. Arluzea; 20. Laño.

as the upper level would represent the accumulation of particles originated by both phenomena.

It is possible that many of the above mentioned causes, and perhaps some others still to be suggested, have been operating throughout the life history on Earth provoking more or less important extinctions. In some cases only quantitative decreases in one or more groups can be detected, whereas in those moments when more determinant factors are involved, extinctions of different taxonomic level could be observed depending on the magnitude of the causing agent. These disappearances could include species, families or more

important groups (ammonites, dinosaurs, etc.). But what would it happen if more than one of those causing agents coincide? In some instances it seems evident that certain causes can be related. So, a global climatic cooling could be connected to a marine regression (HALLAM & PERCH-NIELSEN 1990) adding to the extinction of certain tropical faunas that corresponding to other marine invertebrates from the continental shelf. This type of argument has been invoked to explain the gradual selective extinctions of planktonic foraminifera at both sides of the K/T boundary (KELLER 1989). This process could also explain the gradual extinction obser-

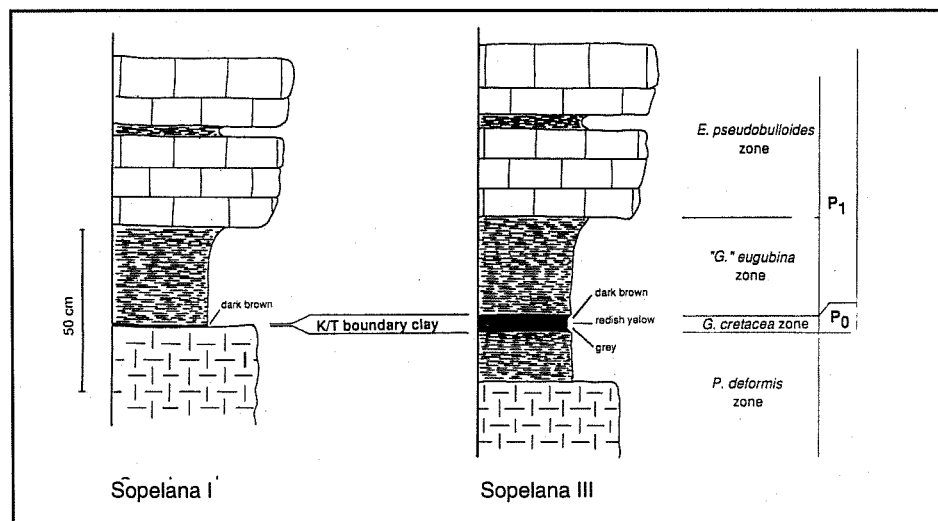


Figure 2.- Detailed stratigraphic columns of the Sopelana K/T boundary sections. 1.- Classic section. 2. New section showing a more complete final Maastrichtian (*Pseudotextularia deformis* zone) and a 7 cms. thick clay exhibiting 3 different coloured levels.

ved in some groups, as the ammonites. Furthermore it is possible to think of a situation similar to the latter plus the addition in a certain moment of another single cause (meteorite, vulcanism, comet rain, etc.). Even several causes at the same time or in an interval of tens or hundreds of years, at the resolution level obtained from the geological record, would seem synchronous. In this way, if many of the agents mentioned so far can have on their own a great incidence on faunal and/or floral annihilations at different taxonomic level, the coincidence of two or more of them would stress profoundly the final result of the extinction. So, all the disappearances known as massive extinctions, and even others not detected yet or not considered as such, could be the final product of a series of consequences derived from some of the above proposed agents acting simultaneously. Then these extinctions should not be necessarily the final result of a single cause even if this would be very important by itself.

CONCLUSIONS

As a conclusion, we believe that there are enough data to think that the extinctions occurred at the K/T boundary were

not the consequence of a unique cause but the final result of some of them, acting simultaneously in some instances. A similar idea has been recently pointed out by other authors (LEARY & RAMPINO, 1990). Following a chronological order, we find a global regression and temperature decrease throughout the upper Maastrichtian generating ecological stress and explaining the gradual extinctions observed on different groups of organisms. To this general situation it should be added the effect caused by great-scaled volcanic emanations represented by the boundary clay. Coinciding with all these, although for a short span of time, the impact of one or more extraterrestrial meteorites should have place.

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