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Frederic Everard Zeuner – a student's appreciation and appraisal

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It is my privilege to be a Ph.D. student of Professor Zeuner, researching Pleistocene mammalian faunas from a number of caves in South Devon, at London University Institute of Archaeology, from 1951–1956; and we remained closely in touch until his untimely death at the age of 58 in 1963 (Fig. 1).

This was a fascinating time for initiation into the mysteries of the Quaternary, inescapably influenced by the ideas expressed by Zeuner in his books, ***The Pleistocene Period*** (1945) and in ***Dating the Past***, first published in 1946 (1946a) and already in its third edition by 1952. A fourth followed in 1958; a second edition of ***The Pleistocene Period*** in 1959. In an unpublished type-script, dated about 1958, preserved in Londons's Natural History Museum, Zeuner personally defined his interests: "All my work has converged on one central problem, namely changes of environment in the geologically recent past and the reactions of life to such changes. In order to do this, I studied both geology (including mineralogy and geography) and palaeontology (with zoology and some botany).... I have restricted myself to terrestrial phenomena and shore-lines....".

Fig. 1. Frederic Zeuner, during the field trip on Dartmoor, Devon, in 1961. One of his party listens intendly during a stop for coffee. This is how his students will best remember him. Photo: A. J. Sutcliffe

For me, three aspects of Zeuner's work stand above his many other achievements. Firstly, with German as his first language, with knowledge of other European languages and with extensive field experience on the Continent of Europe, he was able, after his arrival in England in 1934, to begin integrating British and Continental studies of the Quaternary in a way that few had been able to attempt previously. Secondly, his combined interest in both earth and life sciences greatly boosted the development of Quaternary studies as the multi-disciplinary operation that it has become today. Thirdly, Zeuner's interest in the Astronomical Theory of Milankovitch and earlier writers, which provided the nearest approach to an absolute time scale available at that time and which he supplemented with evidence from his own observations on such diverse lines of evidence as weathering of loess, sea-level change and changing mammalian faunas, was to set the scene in Britain for the acceptance of a Quaternary of many and repeated fluctuations of climate. These achievements are even more remarkable in the context of more limited opportunities for academic communication at this time and the range of scientific techniques available. Literature on Quaternary topics was available in plenty, but in diverse languages and, with the exception of a relatively small number of books, mostly scattered through publications that were not primarily concerned with the Quaternary. Examination of his vast collection of reprints, now preserved in the Palaeontology Library of the Natural History Museum, demonstrates the breadth of his interests and the esteem in which he was held by his colleagues. Zeuner's work on the Quaternary was not based solely on his command of the literature. He travelled extensively and undertook a wide range of field investigations. He missed no opportunity for attending conferences and visiting others who were working in the field. So he buildt up a wealth of knowledge about the Quaternary, that was unique within his time. Zeuner was among the last of those who could try to bring the whole of the Quaternary

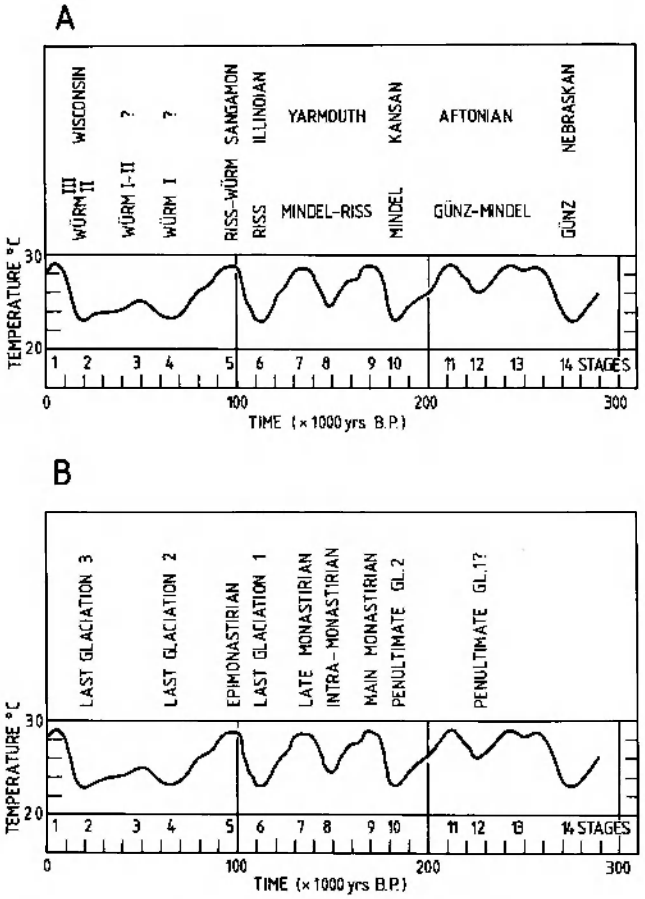

Fig. 2. Generalized temperature variation based on temperature graphs of deep sea cores and the astronomical time scale: a) from Emilani, 1955; b) from Zeuner, 1959, with his re-interpretation of the climatic phases.

together. So great has specilisation subsequently become that this no longer lies within the grasp of a single person.

Influenced especially by the work of Milankovitch, a Quaternary composed of many climatic fluctuations was to be foremost among the ideas promoted by Zeuner; but the testing and ultimate refinement of this hypothesis was dependent on the establishment of a framework of absolute dates; and here he was at a disadvantage, since most of the methods of dating that are taken for granted today had not yet been devised or were still in their infancy. He was nevertheless quick to recognise the potential of the new methods that were becoming available. He wrote (1950, 1955) of the importance of radiocarbon dating. With a then range of only about 30,000 years before the present, however, it was applicable only to the most recent part of Quaternary time. Potassium-argon dating (Evernden *et al.*, 1957), he considered (1959), was likely to become important.

Concurrently with the development of these new methods of radioactive dating, early deep-sea oxygen isotope investigations were opening the door to what later to become generally accepted as the best yardstick to which individual events within the Quaternary could be related. Emiliani (1955) produced a diagram (Fig. 2a), showing fourteen numbered stages. By extrapolating rates of sedimentation based on radiocarbon dating, he estimated that these represented about 280,000 years; the Günz glaciation being provisionally correlated with oxygen isotope stage 14. While accepting that agreement between Emiliani's temperature curve and the curve for summer radiation during the last 300,000 years was too good to be regarded as fortuitous, Zeuner (1959) nevertheless failed to agree with Emilani's correlation of temperature minima, pointing out that the Riss, Mindel and Günz glaciations were shown as single events, whereas the actual sequence was known to be more complex. In the revised interpretation of Emiliani's diagram (Fig. 2b) he proposed that only the uppermost part of the Quaternary was represented there, thus heralding the expanded oxygen isotope sequence that forms the basis for most Quaternary chronological studies today. In the concluding paragraph of the 1959 edition of ***The Pleistocene Period*** Zeuner wrote: "There are certainly great possibilities in radioactivity dating of the Pleistocene, but close and understanding cooperation will be required between geologists, pedologists, chemists and physicists". Since he died only a few years later, Zeuner was unable to find out how his work would stand up to the scrutiny of the teams of specialists who were later to bring this dream to fruition.

We must briefly consider the climate of opinion that prevailed when Zeuner was himself a student and by which his own work was to be influenced. The idea of a Quaternary made up of many, repeated, climatic cycles, which he was to champion and develop so strongly, was already far from new. Ball (1891), influenced by the work of Croll (1875), had concluded, from astronomical evidence, that a succession of Ice Ages, of varied severity and at irregular intervals, must have occurred. He wrote: "Perhaps it would hardly be an exaggeration to assert that, even if geologists had not hitherto discovered the Ice Age from its record on the globe's surface, astronomers would have demonstrated by calculation that Ice Ages must have happened, and would even now be urging geologists to go and look for their traces". He believed that glacial and interglacial episodes alternated in northern and southern hemispheres; although if it were to be shown that the Ice Age in the two hemispheres were concurrent, then the Astronomical doctrine would have to be abandoned.

With further astronomical studies and additional field data, claims were soon appearing for complex sequence of Quaternary climatic events. Soergel (1926), following the terrace studies of Penck and Brückner and the radiation studies of Milankovitch, applied to the Pleistocene by Köppen, constructed a table of Quaternary climatic events showing even greater subdivision. In this his 'Letzte (Riss–Würm) Zwischeneiszeit' has three warm and two cold phases; his 'Vorletzte (Mindel–Riss) Zwischeneiszeit' two warm phases separated by a cold phase. Soergel also wrote extensively on the subject of Quaternary mammals.

Zeuner studied for a Ph.D. under Soergel, by whose work he was much influenced. In his thesis he described the now classic investigation of the tectonically uplifted terraces of the Bardo gorge in the Sudeten Mountains, then in Germany, now in Poland. His Ph.D. was awarded in 1927, with first class honours, and published in 1928.

Soon, he published results of his prominent investigations in Silesia (now SW Poland), dealing with the Pleistocene stratigraphy and climate (Zeuner, 1929, 1932, 1934a), fluvial terraces (Zeuner, 1934b, 1935) and glacial geology (Zeuner & Schulz, 1931; Zeuner, 1934b). He received a Dr. Habil. for a thesis on Tertiary insect palaeontology in 1931, during which year he obtained the post of Lecturer and Senior Assistant at the University of Freiburg-in-Breisgau.

In 1934 Zeuner's career was to be abruptly disrupted by developments in Nazi Germany. Jewish scientists were losing their jobs and, although not Jewish himself, his wife, Etta, was; and he decided to move with her and his young son Wolfgang to start a new life in England. A second son, Christopher, was born later. Zeuner's re-establishment as a leading scientist, in England, was to be the next great achievement of his life. Probably initially assisted by British Jewish organisations, who were sponsoring refugees at this time, by 1935 he had become Honorary Lecturer in Geomorphology at London Institute of Archaeology, established that year at St. John's Lodge in Regent's Park. Having obtained British nationality before the war he escaped internment as an enemy alien, although other relatives of Mrs Zeuner, who had arrived in England later, were less fortunate. During the war he worked at the Anti-Locust Research Centre in South Kensington; he was awarded as D.Sc. for his work on Orthoptera in 1942. In 1946 the Institute of Archaeology was taken over financially by London University, and he obtained a post, first part-time, later full-time, as Professor of Environmental Archaeology. For those of us who were to become his students, Zeuner's coming to England was a stroke of good fortune, which was greatly to influence our future careers; in my case to be at the Natural History Museum in London.

In addition to writing three books, ***The Pleistocene Period***, ***Dating the Past*** and, later, ***A History of Domesticated Animals***, more than 200 papers were also published. Of these, over 50 were on the subject of fossil and living insects, and will not be discussed here. The rest concern mainly Quaternary topics - glacial and periglacial processes and events (including moraines, solifluction and loess), pluvial episodes, river terraces, cave deposits, weathering and soils, fauna and flora, Early Man and archaeology; all seen in the context of a chronology of repeatedly changing climatic events, as postulated by Milankovitch. Coverage was worldwide, with special emphasis on localities where Zeuner had worked himself - in Europe, East and North Africa, Jordan, Lebanon, India and the Canary Islands.

Two important papers appeared almost immediately after Zeuner's arrival in England. In the first of these (1935), *The Pleistocene Chronology of Central Europe*, he discussed the relationships of Silesian and Thuringian river terraces, North German and Polish end moraines, South German and Ukrainian loess and archaeology to the Alpine Chronology. By 1937 Zeuner was able to start making detailed comparison of the Quaternary of England and the Continent. In his paper *A comparison of the Pleistocene of East Anglia with that of Germany* (1937) he compared, with lengthy lists, the mammalian faunas of the Cromer Forest Bed, Norfolk, England, Mosbach near Mainz, Mauer near Heidelberg and Süssenborn near Weimar, Germany, and discussed their possible ages. In his further attempts to refine the chronology of the Quaternary, three lines of study interested Zeuner especially: eustatic changes of sea level, river terraces and, to a lesser extent, pluvial episodes.

In his discussion of pluvials (1945) Zeuner suggested a correlation of three pluvial phases of the Mediterranean with the cold stages of the Last Glaciation. He found, however, that this correlation could not be extended to the tropical zone: "... a study of the possibilities of such an approach show clearly that the suggested correlation of certain tropical pluvials with certain glaciations in Europe is only unfounded, but in some cases definitely wrong". Indeed, this view in not far from that of recent Quaternary students.

Zuener wrote extensively on the topic of Quaternary shorelines (most notably 1942, 1945, 1946b, 1952, 1956 and 1962). Accepting that, in areas free of isostatic or tectonic disturbance, eustatic changes of sea-level should be of the same worldwide (high sea-levels being of interglacial age), he adopted a scheme of altitudinally based stage names devised by Depéret and others from localities in the Mediterranean. Also, he followed suggestion of Bull that there had been progressive deepening of the ocean bed somewhere, possibly in the Pacific. Problems began to arise when it was found that the altimetric divisions were being confused with palaeontological divisions established on faunal evidence (*i.e.* Zeuner 1956). Zeuner had no means, during his life time, of obtaining absolute dates for the old shore lines that he was studying, through the more recent development of the uranium series method for dating fossil corals has since produced a wealth of absolute dates and a means of recognising areas of neotectonic disturbance.

Although beginning his terrace work (1928) in montainous areas, Zeuner's works dealt with the lowest courses of rivers where the coast lines merge into estuarine terraces. Zeuner made a study of the terraces of a number of rivers, most notably the Rhine and the Thames (Kimball & Zeuner 1946; Zeuner 1959, 1961). The complexity of the terrace sequence is dramatically illustrated in the profile that forms the long pull-out figure 78 in the second edition of ***The Pleistocene Period***. Zeuner concluded (1962): "It thus appears that the evidence of river terraces connected with sea level oscillations, ocean temperatures, and astronomical evidence of variations in solar radiation are all beginning to present a coherent picture of events during at least the second half of the Pleistocene". This aspect of the Quaternary is still under discussion, and some authors (*e.g.* Bridgland, 1994) have been able to refer many of Zeuner's terraces to the oxygen isotope chronology.

Also of great interest to Zeuner were changing Mammalian faunas and their relationship to the climatic sequence. In a list of nearly thirty sites in England, France, Germany, Switzerland and Italy (1945) he described and discussed the climatic significance of faunas varying in age

from Villafranchian to the end of the Last Glaciation. During his later years Zeuner also developed a special interest in domestication, concluded only shortly before his death with the publication (1963) of his third, greatly to be acclaimed, book, ***History of Domesticated Animals***.

It would be inappropriate here to examine in detail all that has happened in the Quaternary studies during the subsequent years. We are nevertheless concerned with examining how Zeuner's chronological ideas compare with those of today. Three developments would have pleased him especially: the degree to which Quaternary studies have become multi-disciplinary, with specialists from the different disciplines working together; confirmation that astronomical factors indeed had a major influence on climatic changes (Hays *et al.* 1976) and that the number of climatic cycles was considerable; and the improvements in dating methods that have occurred, so that it is now realistic to start relating all events of the Quaternary throughout the world to an absolute time scale. As Zeuner was the precursor in all these three aspects of the Quaternary Science, his influence is still very much alive today.

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