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Methods and Concepts in European Quaternary Stratigraphy — Introduction to Methods for the Study of Stratigraphical Records

Denis-Didier Rousseau

URA CNRS 157 Universite de Bourgogne, Centre des Sciences de la Terre, 6 Bd Gabriel, 21100 Dijon, France

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ABSTRACT

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The International conference "Methods and Concepts in European Quaternary Stratigraphy was held to take stock of the new developed concepts in Quaternary stratigraphy, to compare different approaches and to evaluate the respective results in continental and marine environments

The following papers, presented in this issue, correspond to the theme "Methods for the study of stratigraphical records ' They roughly indicate the average use of different concepts developed in different disciplines to Quaternary records

Two biological objects are described in detail molluscs and pollen They are approached in two different ways

For the former, first of all by using a biogeographical approach based on the biome concept and secondly by trying to demonstrate the stratigraphical value of mollusc assemblages in fluvial deposits

For the latter, first of all by using a dynamic approach to the vegetation cover of the middle mountain area of the Massif Central, France and secondly by using transfer functions to propose temperature and precipitation estimations from two long pollen sequences

A last paper makes an evaluation of different material which can be radiocarbon dated and the reliability of the proposed dates, specially beyond 35,000 yr B P

Ten years ago, European geologists who were dealing with Quaternary study met in Dijon to develop a common strategy concerning Quaternary stratigraphy (Chaline, 1980) The purpose was to homogenize and redefine a stratigraphical approach according to Hedberg's guide Three major recommendations were proposed (Paepe, 1980)

(1) To develop regional stratigraphies and to delimit the climato-sedimentological area (litho-stratigraphy), the basic approach, and then to propose absolute chronological markers which could finally allow to deduce paleoclimatic cycles

(2) To provide precise field survey, included in a regional cartography, which allows to define the boundaries of type regions

(3) Reorganization of the continental stratigraphies to allow a new balance of the regional systems by a cleaning of the ancient classifications Were these recommendations followed? and in the positive case, did they allow the occurrence of new methods and concepts in Quaternary study?

The international conference "Methods and Concepts in Quaternary Stratigraphy" tried to take stock of the new approaches recently developed in Quaternary stratigraphy, to compare and to evaluate the respective results of these different approaches with a proeminescence to continental environment The meeting organized by D D Rousseau, M Campy and J Chaline took place in Dijon on December 5–7, 1988

Why such a meeting concerning European Quaternary?

For a long time, Penck and Bruckner's (1909)

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work in the alpine area marked the Quaternary stratigraphy very much They defined a so-called "alpine" chronostratigraphy, widely known, while it only concerned the glacial episodes recorded in this restricted area Nevertheless, the reference to this European motherland was progressively reduced time after time to the advantage of, on the one hand a Northern nomenclature and, on the other hand to a marine isotopic chronostratigraphy (Imbrie et al , 1984) deduced from numerous oceanic cores The latter, as also the arctic and antarctic ice cores were studied within the scope of great multidisciplinary projects in which climatic problematics is in the first place (CLIMAP, 1976, 1981, Jouzel et al , 1989)

This is the reason why continental stratigraphies, which for the most part claimed a general value, were replaced by the proposals of regional values These ones, necessary in the first step of the investigation, rarely emerged onto more synthetic conceiving Consequently, the reference to these sequences progressively diminished

Do we have thus to notice the impossibility for using continental sequences resolving problems of European Quaternary stratigraphy in spite of an intense activity under the aegis of SEQS (Chaline, 1987)? For several years (Chaline, 1980), the stratigraphical approach of the Quaternary has been under the process of modernization as well conceptual as methodological, a reflection of the scientific renewal observed among the geosciences (Campy and Macaire, 1989, Campy and Chaline, 1987)

Continental Quaternary deposits offer scientists a high diversity of observations, in rich and various contexts, which allow multidisciplinary studies, comparable to marine projects (Van Kolfschoten and Roebroeks, 1985, Pons et al , 1988, Tuffreau and Sommé, 1989, Peteet et al , 1990) The connection between local stratigraphy and climatostratigraphy is the chance for "continentalists" because they have a great and undeniable advantage of field observation over large areas (Kukla and An, 1989, Pillans and Wright, 1990)

This is the reason why the "Long Terrestrial Records" of the INQUA commission on stratigraphy was created (Adam and Rousseau, 1988, Kukla, 1989) and why the MCQS was held in order to test the value of the different approaches applied to continental Quaternary sediments and to compare them with marine data

Associated with the progress made in stratigraphy, mainly due to a multidisciplinary approach, paleobiologists s l have to apply new concepts, developed in their own disciplines, to Quaternary study The papers presented in this issue contribute to the presentation of these adapted concepts

The first two papers concern terrestrial molluscs The integration of numerous data, yielded by investigations over a large area, is a problem which biogeography can analyze The recent progress in biogeography allows to determine narrative and hypothetical-deductive approaches of which the philosophies completely differ The former manages its interpretation to provide an ultimate conclusion which could not change The latter proposes hypotheses which need to be evaluated by biological, or other studies The thought is always in process and allows to clearly weigh different factors which act on life historical and ecological ones Following this concept of ecological biogeography, Rousseau et al (1990) criticize the ecostratigraphical concept defined by Martinsson (1973) Using the biome concept (unifying zoological and botanical peopling) to pleniglacial molluscs Rousseau et al examine the variations of these assemblages over central and western Europe, mainly within the loess belt The impoverishment of the mollusc assemblages to the west, classically observed by Lozek (1964) and Puisségur (1976), is interpreted following the ecological biogeographical concept as indicating variations of the precipitation regime which allow to determine a western to central-European, more continental, domain Integrating the mollusc investigations made on long terrestrial sequences, the authors propose variations of the boundaries of the two domains through time

Keen (1990) tackles the significance of molluscan faunas in fluvial deposits Long time ago molluscan assemblages appeared problematic because of their components Generally, these faunas belong to two main groups the first, a mixed terrestrial and freshwater assemblage and the second, an exclusive aquatic one Generally, these assemblages are used to reconstruct the local

environments while the exact significance of the mixed assemblages are questioned because of the problem of reworked material The stratigraphical interpretation is also firmly rejected by British authors Working in a well-determined stratigraphical area, Keen (1990) attempted to resolve these problems According to the different types of deposit, the determined mollusc assemblages characterize local climatic variations or indicate biostratigraphic information Interstadial and interglacial faunas can be distinguished, which allow to discriminate episodes of temperate deposition that palynology or another biological approach cannot distinguish

The following papers are concerned with botanical investigations They propose two complementary approaches which correspond to the recent trends in this disciplinary

First, applying a phytogeographical approach, Reille and Beaulieu (1990) present a new pollen sequence located in France This pollen sequence recorded almost the most recent climatic cycle, except interglacial stage 5e Following the 1980 recommendations, the stratigraphy is defined according to the regional context with local names Then the botanical history allows to characterize two forested interstadial stages (St Geneys 1 and 2) which are determined for the first time in this country Up until now, these interstadials were characterized in France at La Grande Pile, in relation with the Vosges glaciers (Woillard, 1978), and in Les Echets (in relation with the alpine glaciation (Beaulieu and Reille, 1984) The good fit of this sequence obtained in the French Massif Central which is in a more southern position than the previous ones, Les Echets and Le Bouchet belong to the same phytogeographical region, allows a better understanding of the pollen evolution during the last climatic cycle While Les Echets and Le Bouchet indicate a difference of 1000 m in elevation, the dynamics of the vegetation is the same during the two interstadial stages, suggesting temperate conditions Consequently for this analysis, this sequence appears to be a reference, for middle mountains of western Europe, for the last climatic cycle, except the equivalent of interglacial isotopic stage 5e

The classical extension of the previous analysis is the quantitative paleoclimatology and study of continental records which allow to propose climatic estimates determined from pollen, insects, molluscs and tree rings Because they yield numerous fossil remains, long terrestrial records, as marine sequences, allow to characterize the climatic variations The quantification of the climatic estimates has been applied for several years on pollen data The results are consistent with other results, specially with those obtained in marine sequence from microfossils Nevertheless, J Guiot has been developing a new method of quantitative paleoclimatology from pollen data since 1987 After a clear presentation of the mathematical process, the definition of the "paleobioclimates" and determination of modern reference set for the entire Palearctic area, the method is applied to two long sequences which record the last climatic cycle (Les Echets and La Grande Pile) (Guiot, 1990) The temperature and precipitation estimates constitute a large data set which contribute to a better understanding of climatic variations over western Europe during the last interglacial–glacial cycle The evaluation of these results with other data as insolation allows to test, in a continental context, the climatic mechanisms proposed by Ruddiman and McIntyre (1981) to explain continental ice growth

Finally, a well-established stratigraphy, in continental as well as in marine environments, is now really significant when radiometric dates are available While datings are one of many stratigraphical elements, they constitute well-developed technics which sometimes could contribute to forget the reality of field investigations For some years, new methods have been proposed, thermoluminescence, amino acids or dating methods have been improved, following the technological progress (Accelerator Mass Spectrometry) The latter has been largely used for several years in studies dealing with the last deglaciation The precision of the dates is so important that a large literature is available concerning the recognition, the occurrence or absence in a determined area of a small event such as the Younger Dryas In the fifth paper, J Evin reevaluates the validity of radiocarbon dates beyond 35,000 yr B P taking into account the nature of the material used (1990)

The conference "Methods and Concepts in Quaternary Stratigraphy" was divided into four themes The name of authors in italics for the contributions to the theme 2 corresponds to papers in this issue Other papers are published in "Quaternaire" and "Quaternary Science Reviews" They are respectively checked off by (Q) or (QSR)

Inaugural lecture A Berger Astronomical theory of paleoclimates during the last Glacial–Interglacial cycle (QSR)

Theme 1: Value and significance of the stratigraphical record

Plenary lecture C Schluchter Terrestrial Quaternary stratigraphy (= Lithostratigraphy) — incomplete, but the basic reference nevertheless (QSR)
J Sommé Sedimentary environment records and Quaternary stratigraphy (Q)
P Gibbard and C Turner Type sections for Pleistocene cold stages some thoughts on a difficult problem (Q)
P Ambert and G Clauzon Geomorphological contribution to Quaternary stratigraphy river terrace genesis in the Mediterranean areas of France
J J Macaire Time recording in fluvial superficial deposits from geodynamic to chronostratigraphy (Q)
M Léger Interest and significance of stratigraphic signals in moraines, alluvions and loess of the Northern Piedmont of the Alps
M Cremaschi Depositional and post-depositional processes in rock shelters of Northern Italy during late Pleistocene, and their palaeoenvironmental significance (Q)
B Van Vliet-Lanoé The Warneton pedocomplex present state of the question? Palaeopedological and micromorphological budget (Q)
P Bertran and J P Texier Record of pedological, sedimentary and climatic phenomena in colluvial deposits the example of the Les Tares sequence (Dordogne, France) (Q)

Theme 2: Methods for the study of the stratigraphical record

Plenary lecture J Chaline Problematic of the stratigraphical markers methods and limits
D D Rousseau Biogeography of the Pleistocene pleniglacial malacofaunas in Europe Stratigraphic implications
D Keen Significance of the record provided by Pleistocene fluvial deposits and their included molluscan faunas for palaeoenvironmental reconstruction and stratigraphy
M F Bonifay Critical observation on big European Plio-Pleistocene faunas Limits and interest
J M Cordy Contribution of micromammal faunas of Belgium to the knowledge of the upper Quaternary in northwest Europe
J L de Beaulieu Pollen analysis and European Quaternary stratigraphy limits, progress and prospects
A V Munaut The importance of the choice of a biogeographical model in order to establish a palynological stratigraphy all along the Quaternary epoch
N Combourieu-Nebout Climatic evolution in Mediterranean area and high latitudes insolation for 2 4 to 1 1 Ma
J Guiot, A Pons, J L de Beaulieu and M Reille Numerical reconstruction of the last climatic cycle based on two pollen cores from France
B Frenzel The use of electron microscope for Quaternary stratigraphy
A Tuffreau Chronostratigraphical signification of Palaeolithic industries the case study of Northern France
F Djindjian The value of the Paleolithic industries as stratigraphical markers
J Evin Limits in using the radiocarbon method in the different types of Quaternary sediments
J C Fontes Problems in using ^{14}C radiochronometry
C Causse and C Hillaire-Marcel Th/U-dating of open carbonate systems

Theme 3: Problems of stratigraphical correlations

Plenary lecture G Kukla Present state of the correlation of European and Chinese loess stratigraphy with deep sea sediments

J C Duplessy Continent-ocean correlations during a climatic transition the example of the last deglaciation
J P Lautridou, M Clet, J P Coutard, J C Descombes, M Helluin, M F Huault, P Lebret,

C Lechevallier, F Lécolle, D Lefebvre, S Occhietti, J C Ozouf, J Pellerin, D D Rousseau and B Van Vliet-Lanoe Relations between Pleistocene marine and continental formations in Normandy (France)

G Seret, E Dricot, M Petillon and L Huysmans Paleoclimates and glacier changes after the Eemian Interglacial in the southern Vosges mountains (France)

J L Turon Ocean/continent correlations based on some marine records

E Van Campo Diversity and interpretative constraints in marine pollen records

M Strick and E Van Campo Interhemispheric correlation between south low latitudes and western Mediterranean during the last climatic cycle

Theme 4: Place and range of Quaternary into Cenozoic

Plenary lecture

W H Zagwijn The beginning of the ice age in Europe and its major subdivisions (QSR)

J P Suc and N Combourieu-Nebout Palynology and Plio-Pleistocene boundary

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