Fluvial sequences as evidence for landscape and climatic evolution in the Late Cenozoic

[Follow-on IGCP project, building on the achievements of IGCP 449]

Aims:

To chart the history of landscape evolution, including crustal movements, from fluvial records and comparison with other proxies

To investigate and enhance correlation between fluvial and climatic records and causal relations between them

To further build the database of fluvial records started under IGCP 449

Rationale

The follow-up project seeks to continue the compilation of valuable fluvial records from around the World that was initiated as part of IGCP 449. In so doing it will highlight the key applications identified in the title: (1) the palaeoenvironmental (including biostratigraphical) evidence available from fluvial sequences, which is often critical for dating and/or correlation with the global marine record, and (2) the information that fluvial sequences, particularly river terraces, provide about Late Cenozoic landscape evolution. The full value of the second of these came to light during the original project, as patterns of differently disposed deposits became apparent, related to different crustal types and different patterns of uplift.

Output will be by publication, building on the stream of special issues initiated under IGCP 449, and by continuing to build the internet database of fluvial sequences established under the initial project.

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PROPOSED FOLLOW-UP PROJECT FOR THE INTERNATIONAL GEOSCIENCE PROGRAMME

(to build on IGCP 449)

INTRODUCTION

IGCP 449 (Global Correlation of Late Cenozoic fluvial deposits) instigated the compilation of fluvial records from all over the World, engaging countries as widely separated as Australia, Brazil, Canada, India, Morocco, Russia, South Africa and Turkey. It was always known, however, that the project would be building upon an already-well-researched body of European data, and so it proved. To this European resource has been added significant quantities of data from pre-existing research in the former Soviet Block, now made accessible in English-language publications for the first time (Appendices A, C, D & F). Research on fluvial sequences elsewhere in the World remains rather patchy, a situation that, perhaps surprisingly, pertains in North as well as South America. There are important records from the Middle East and from India and China, but a large part of the tropical and equatorial zones remains poorly represented.

The follow-up project will seek to continue the task of data collection initiated by Project 449, to extend the coverage to new countries and river systems, and to continue the compilation of the internet database started under the initial project. At the same time, it will develop specific themes that were found, during the initial project, to be innovative and of potential importance to various branches of the Earth Sciences, as will be explained below. The rationale for the follow-up project is thus broadly similar to that of Project 449, although its title reflects the themes it plans to develop, beyond the overarching task of correlation.

Within their geomorphological and sedimentary records, rivers provide valuable archives of global change. Specifically, the sedimentary records left by rivers represent considerable databanks of palaeoclimatic and palaeoenvironmental information, as demonstrated by the data amassed as part of the IGCP 449 programme. In particular, fluvial archives are repositories for fossils and archaeological material, which provide important evidence about biotic evolution and early human occupation, respectively, as well as being of value for biostratigraphical and relative dating. Subthemes within the initial project, devoted to these interests and reporting separately, will be continued within the follow-up project. These lines of evidence contribute to the general palaeo-environmental interpretation of fluvial sequences, which also benefits from sedimentological and other palaeoclimatic evidence (e.g. periglacial structure; soil-formation evidence).

The physical disposition of fluvial sequences, be it as fragmented terrace remnants or as stacked basin-fills, provides valuable information about crustal evolution. Although that was already known prior to the start of IGCP 449, the discovery of different preservational patterns of fluvial records in different types of crust - ancient crust (Archaean or older) as opposed to post-Archaean crust - has been an important unforeseen result of the initial project (Westaway et al., 2003a; Bridgland & Westaway, in press) and contributes to the modified rationale for the follow-up project.

The substantial progress that has been made in recent decades in the description and interpretation of late Cenozoic and, especially, Quaternary fluvial sequences has thus been further advanced by the activities of IGCP 449. This research has involved a wide and growing range of disciplines, including geomorphology, sedimentology, palaeontology, archaeology and mathematical modelling. The latter project benefitted from a close relationship with the pre-existing Fluvial Archive Group (FLAG), a research group that was established in 1996 under the auspices of the British Quaternary Research Association. This relationship included representation of IGCP 449 within biennial FLAG conferences during 2002, 2002 and 2004, and in the resultant conference proceedings publications (Appendices A & C).

The original project was timely in the light of recent advances in methodology for the study of fluvial systems and their sedimentary sequences and in the understanding of the Cenozoic palaeoenvironmental record in general, particularly in relation to the globally valid oxygen isotope record from oceanic sediments (cf. Shackleton & Opdyke, 1973; Bassinot *et al*., 1994). Since river sequences can be used to link the oceanic record into the interiors of continents, fluvial archives provide potential frameworks for continental studies – a major thrust of IGCP 449. Frameworks thus established can provide a structure onto which high-resolution studies can be built, as well as contexts for a variety of related disciplines (e.g. faunal evolution, human occupation and migration, late Cenozoic environmental change). Project 449 has made significant advances towards the goal of correlating Late Cenozoic terrestrial and oceanic records, by using the globally valid marine record as a template for correlation and comparison between fluvial sequences in different parts of the World (Bridgland *et al*., 2004a). In the future project the expanding record from ice cores (Augustin *et al*., 2004) may become increasingly important as a potential palaeo-environmental template. As ever, a combination of relative and absolute dating of the fluvial record will be required to relate it to the template(s).

AIMS AND OBJECTIVES

The new project aims to continue the compilation and dissemination of data on long fluviatile sequences that started under IGCP 449. Such sequences are of major significance in that potentially they can provide frameworks for Cenozoic sequences on land. IGCP 449 has instigated the first systematic collection of data on Late Cenozoic fluvial sequences from around the World and has made it available in a readily accessible format, by publications and on the growing internet database. In the new project emphasis will continue to be given to assembling data in a readily digestible format, with use of summary diagrams and tables.

Specific objectives:

- ♦ Completion of the internet database of well-dated Late Cenozoic fluvial sequences from all parts of the World.
- ♦ Determining the optimum way of designing and compiling this database, so that it is readily assembled and supplemented and is accessible to search engines.
- ♦ The database will eventually include the most important fluvial archives, some designated as regional fluvial stratotypes, with which less well-dated sequences, partial sequences and sequences from other environments can be compared.
- ♦ The project will promote the use of the fluvial data resource in the evaluation of evidence for palaeoclimate, in connection with dating and stratigraphical data.
- ♦ The project will promote the use of the fluvial data resource in the evaluation of implications for landscape evolution, relating incision and base-level changes, variations in valley width and other features to stratigraphy and other evidence of age.
- ♦ The project will promote the correlation of fluvial sequences with the global marine record, by whatever means possible and with emphasis on a multi-proxy approach.
- ♦ Further dissemination of this information will be by publication in journals and books, as well as through meetings to be held both as part of the proposed project and more widely.

BACKGROUND - THE NATURE OF THE DATABANK

Fluvial archives benefit from a global distribution, being represented on all continents and across all climatic zones, with the exception of the polar regions and the driest deserts. While it is clearly impractical to include studies of every river, an essential element of this project will be to integrate representative information from the full geographical range. Staircases of large-scale aggradational river terraces are a notable feature of many valleys in the temperate latitudes, particularly in areas beyond the reach of the erosive activities of Pleistocene ice sheets. The reconstruction of longitudinal profiles represents the main tool for correlation of often very fragmentary former floodplain remnants. Correlation can be additionally undertaken using sediment composition (e.g. clast lithologies, mineralogy, erratic input), biostratigraphy and geochronology (see below).

It is now recognized that the cyclic fluctuations of climate during the Quaternary have driven the generation of terraces, through the direct and indirect influence of both temperature and precipitation on fluviatile activity (Bull, 1991; Bridgland, 1994, 2000; Starkel, 2003; Vandenberghe, 2003). Climatic forcing alone is insufficient to cause terraces to form, however; surface uplift is also necessary, so that terrace sequences can also provide a useful record of crustal movement. If river terraces can be dated, they can provide a means of gauging landscape change, since they record successive valley-floor levels, as well as course diversions and changes in valley width. Terrace sequences can thus provide a framework for modelling fluvial incision as a part of landscape evolution (Maddy, 1997; Maddy *et al*., 2000; Westaway *et al*., 2002). Fluvial incision is believed to be a direct response to surface uplift and can therefore provide a measure of the amount of this uplift (Van den Berg, 1994, 1996).

Not all fluvial deposits underlie terraces, however (NB a distinction should be made between the terrace landform and its underlying sediment). In subsiding sedimentary basins, grabens, aulacogens and, in many continental shelf areas, thick piles of river sediments have accumulated during the Cenozoic. Study of these has not always been easy, generally relying on boreholes and geophysical techniques to determine the geometry and nature of buried and sometimes submerged sequences and channels (e.g. Ruegg, 1994; Yim, 1994; Alekseev & Drouchits, 2004; Veligrakis *et al.*, 1999; Bridgland, 2001; Patyk-Kara and Postolenko, 2004).

Spatial Scales

Project 449 started with the knowledge that there existed an ample but poorly coordinated supply of data from the temperate latitudes of Eurasia, where the normal river development during the late Cenozoic has been to form staircases of terrace deposits (except in areas of subsidence). These staircases have been formed in response to climatic forcing, which has led to cyclic incision and aggradation in synchrony with glacial/interglacial cycles, superimposed upon a background of progressive uplift (Bridgland, 1994, 2000; Maddy, 1997; Westaway et *al*., 2002; Starkel, 2003). In areas that have not experienced uplift, the climatic signal is still reflected by alternations of deposition and erosion (e.g. Vandenberghe, 1995), but rejuvenation and valley incision has not occurred (e.g. the lower Rhine; Brunnacker *et al*., 1982). Similarly, the sequences beneath the southern Gangetic plains in India consist of discontinuity-bounded units that reflect alternate floodplain aggradation and degradation (Sinha *et al*., 2002; Gibling *et al*. in press; Tandon *et al*., in press; Sinha *et al*., in press).

Because of the wealth of data from NW Europe, this area formed the starting point for IGCP 449 and the project subsequently extended, by collecting comparative data, into other regions. Data from outside this core area was thus added, notably from central & eastern Europe, southern Europe, North America, North Africa and the Near East. The more distant regions of the Middle East, Asia, Australasia, sub-Saharan Africa and South America, which were targeted for later phases of the project, have been covered in part, although data remains patchy (see below). The gaps in coverage will be particular targets for the follow-up project (see Work Plan).

Temporal Scales

The main emphasis of the initial project (IGCP 449) was the past 1Ma. This was because the vast majority of the well-preserved fluvial sequences and much of the available dating evidence fall within that timescale. That is also the period during which rivers in many parts of the World can be seen to have been responding to the 100 ka eccentricity cycles, which became dominant at about 800 ka (Ruddiman *et al*., 1986). One of the findings to emerge as the IGCP 449 database accumulated was that patterns of fluvial sediment preservation, particularly as terraces, indicate changes in fluvial incision and valley form over time. These can be shown to relate to periods of faster uplift at different times during the Late Cenozoic, their timing perhaps coupled to Earth surface systems (Van den Berg, 1996; Westaway, 2001, 2002a, b, c). These temporal variations in fluvial activity, which have had a profound effect on landscape evolution, are superimposed on differences in response in relation to different crustal types (Westaway *et al*., 2003a). To examine these patterns further, the new project will seek out the rarer records from earlier parts of the Late Cenozoic as well as adding further examples of the more recent Quaternary sequences from areas of the World in which these are as yet unknown.

OVERARCHING RATIONALE

It is recognized that the new project needs to engage scientists in areas poorly represented within Project 449, while at the same time continuing to involve those who contributed to the initial project. The best way to ensure the latter is to provide new aims, namely the investigation of landscape and climatic evolution as recorded in the fluvial sequences already documented.

METHODOLOGY

The recent development of enhanced dating techniques applicable to fluvial sequences made the initial project, IGCP 449, extremely timely, as these have been of considerable assistance in the correlation process. Important advances in this respect have been:

- Improved understanding of biostratigraphy, especially using animal fossils, the primary basis for relative dating;
- Application of enhanced absolute dating techniques, notably luminescence techniques, as well as calibrated relative methods such as amino acid geochronology;
- Recognition of critical stratigraphic markers provided by magnetic reversals, glaciations, marine transgressions, volcanic eruptions, etc., which can often be linked with geochronological studies (e.g. dating of interbedded lavas using potassium – argon or argon – argon methods);
- Regionally, within parts of the 'Old World', anthropogenic artefact assemblages provide a means of relative dating;
- At least regionally, the progressive valley incision recorded by terrace formation can provide a broad guide to age. The improved interpretation now possible for this type of record has led to enhanced understanding of landscape evolution, with significant advances made during the course of IGCP 449, directly as a result of the accumulating data archive (see Westaway *et al*., 2003a; see also below, p. 14).

Together with more traditional field-based methods, the above advances have allowed the formulation of a multidisciplinary methodological framework for the investigation of fluvial sequences, involving teams of specialists with expertise in geomorphology, stratigraphy, sedimentology, palaeontology, archaeology and geochronology. The cumulative results can be

seen in the IGCP 449 internet database:
http://www.geography.dur.ac.uk/research/igcp_449/igcp_449.html
(see below, p. 15)

Lithostratigraphy

Fundamental to the utilization of fluvial archives is the establishment of a secure lithostratigraphical framework within which the additional palaeoenvironmental and palaeoclimatic data can be placed. Formal lithostratigraphy (cf Hedberg, 1976) has seldom been undertaken in the case of river terraces except in the UK and North America, workers elsewhere preferring informal geomorphology-based nomenclature. It is clearly desirable to make use of nomenclature that is already well established; this is and will continue to be the normal policy.

Biostratigraphy

This is a traditional and well-tried method for establishing relative chronologies for fluviatile sequences. Applicable only where fossiliferous sediments have been preserved, the method has proved useful in many parts of the World. The best fossil groups are those that can be identified readily to species level and those that have undergone significant evolutionary change within the late Cenozoic. Others may provide valuable palaeoenvironmental data that can be fed into climato-stratigraphic reconstructions. Expertise is available in academic departments and museums, the latter often holding significant archives of faunal material collected over many decades. Details of availability are given in Table 1. The most important groups are as follows:

Vertebrates: These include land animals as well as fish and other aquatic vertebrates. Recent work suggests that mammalian fossils offer the most powerful tool for correlation of fluvial sequences with the global marine record of glacials and interglacials (Preece & Parfitt, 2000; Stuart & Lister, 2001; Schreve, 2001a, b; Schreve & Bridgland, 2002b; Auguste *et al*., 2003; Matoshko *et al*., 2004; Ubilla, 2004). The bones and teeth of large mammals are commonly found in fluviatile deposits, probably because animal carcasses often find their way into rivers. Vertebrate remains from river deposits sometimes include hominid fossils, such as at Swanscombe, UK, in the Thames sequence (Conway *et al*., 1996), and Steinheim, Germany, within sediments of the River Murr (Adam *et al*., 1995). At another German fluvial site, Mauer, in the Neckar system, a hominid mandible from fluviatile sands represents the type specimen of *Homo heidelbergenisis*. Mammals are especially valuable for biostratigraphy, as they have undergone considerable evolution and numerous extinctions during the Neogene and

Quaternary (Horacek, 1990). Small mammals and other small vertebrates are readily obtained from systematically collected samples by sieving (Rabeder, 1974, 1981; Fejfar & Heinrich, 1983).

Molluscs: With terrestrial, freshwater, brackish and marine representatives, molluscs can record nearby land habitats as well as, in the lower reaches of rivers, the transition to the marine environment. Thus they allow sea-level changes at the downstream ends of river courses to be detected (Markova & Mihailescu, 1994; Bridgland *et al*., 1999, 2001). The Mollusca supply important biostratigraphical and palaeoenvironmental information (Lozek, 1964a, 1964b; Horacek & Lozek, 1988; Keen, 1990, 2001; Kovanda *et al.,* 1995; Preece, 1995, 1999, 2001; Antoine & Limondin-Louzouet, 2004) and, in recent years, have provided the raw material for the powerful geochronological method based on the epimerization of amino acids within mollusc shells (Miller *et al*., 1979; Bowen *et al*., 1989, 1995; Bates, 1994; Penckman *et al*., 2003). Molluscs are also extremely important climato-stratigraphical tools, since they provide reliable evidence for palaeoclimate and palaeoenvironmental conditions.

Palaeobotany: This includes the study of pollen and spores, as well as macroscopic plant remains. Pollen, recognized as the most widespread source of environmental and stratigraphical evidence since the study of the Pleistocene interglacials began (Pike & Godwin, 1953; West, 1956; Zagwijn, 1985), is often present in organic fluviatile sediments, such as those representing infilled oxbow lakes. However, these seldom record a large proportion of the time represented by any particular interglacial, in contrast to sequences filling deeper lakes in glaciated areas, which have provided the most complete palynological records of such episodes (cf. Mangerud, 1991; Thomas, 2001). Pollen sequences are particularly important because, even where a relatively brief period is represented, they can reveal at which point in the climatic (glacial-interglacial-glacial) cycle a sediment was laid down. Certain gross characteristics of interglacial pollen records may be of value for distinguishing between particular temperate-climate episodes (Tzedakis & Bennett, 1996; Tzedakis *et al*., 1997; Thomas, 2001).

Macroscopic plant fossils provide valuable additional information, as they allow higher taxonomic resolution than is generally available from palynological data, although it is less easy to undertake quantifiable studies. Species that are poor pollen producers can also be represented.

Ostracods : These provide important palaeoenvironmental information, particularly in relation to marine influences at the downstream ends of rivers. However, they are of limited value for biostratigraphy (Griffiths, 2001).

Beetles : Beetles (Coleoptera) have proved to be perhaps the most sensitive of the fossil groups for the reconstruction of palaeoclimate, using the Mutual Climatic Range Method, which can provide limits of palaeotemperature based on coleopteran assemblages (Atkinson *et al*., 1987). This method is of obvious importance to climato-stratigraphy, but the biostratigaphical value of Coleoptera is equivocal, given their minimal evolution during the late Cenozoic. Beetle preservation in fluvial deposits is patchy and generally restricted to more organic sediment types.

Geochronology

Geochronological methods can be applied to fluvial sequences where opportunities present themselves. Work of this type has been undertaken widely in Europe, North America and India, but less extensively elsewhere. Project 449 was a catalyst for new research of this type, there having been significant contributions during its lifetime (e.g. Agusti *et al*., 2001; Nott *et al*., 2002; Schulte, 2002; Braga *et al*., 2003;Jain *et al*., 2003; Zhang *et al*., 2003; Penkman *et al*., 2003; Singh *et al*., 2003; Srivastava *et al*., 2003a, b; Westaway *et al*., 2003b, 2004a, b; Antoine & Limondin-Louzouet, 2004; Preece *et al*., in press). Geochronological techniques are available in a number of the institutions committed to the project, as follows:

Palaeomagnetism: This method is valuable in providing isochrons (fixed points within sequences). Location of the Matuyama-Brunhes reversal is particularly valuable as a marker for the base of the Middle Pleistocene (780 ka). This marker is an important element in the dating of the Somme (Antoine, 1994) and Alpine (Fink *et al*., 1979) terrace sequences. It also provides an important constraint in dating the Ohio and Susquehanna terrace staircases, as reverse-magnetised glacio-lacustrine sediments cap some of the older river terraces (e.g., Jacobson *et al*., 1988; Ramage *et al*., 1998). It has been suggested (Westaway, 2003) that abrupt changes in the Earth's rate of rotation, caused by changing global ice volume, may have affected the geomagnetic field, from which it follows that geomagnetic excursions in the Middle-Late Pleistocene may correlate with the formation of river terraces. In some river terrace staircases that extend back to before the Pleistocene, other geomagnetic reversals provide additional dating constraints, for instance in the Maas (e.g., Van den Berg & Van Hoof, 2001) and the Dniester (Matoshko *et al*., 2004). Stacked sequences of mainly fluvial sediment that typically pre-date the observed Late Cenozoic increases in uplift rate can also be magnetostratigraphically dated, providing age control for these sediments and age bounds for the start of the Late Cenozoic fluvial incision. Examples are in Spain (Agusti *et al*., 2001; Schulte, 2002; Braga *et al*., 2003; Mather & Stokes, 2003), Greece (van Vugt *et al*., 1998, 2001), India (Sangode & Kumar, 2003; Sanyal *et al*., 2004) and Turkey (Westaway *et al*., 2004a, b).

Amino acid geochronology: This has proved to be one of the most effective geochronological techniques for application to fluviatile sequences in north-west Europe, although it has yet to be widely applied elsewhere. An exception is its application to land snails in the deposits of the Souss valley, Morocco (Occhietti *et al*., 1994; Bhiry & Occhietti, 2004). The method is applicable in temperate latitudes over the last 0.5 Ma, although higher epimerization rates in warmer climates will reduce this range. Recently the development of new preparation techniques has greatly enhanced the reliability of this method (Penkman *et al*., 2003; Preece *et al*., in press).

Luminescence dating: Luminescence methods, applied to grains of quartz and feldspar, allow the direct dating of fluvial sediments. Thermoluminesence (TL) and optically stimulated luminescence (OSL) methods have also been applied to loess overlying river terrace deposits and, in the former case, to anthropogenically burned flints in archaeological contexts within fluvial settings (Preece *et al*., in press). The technique is well developed in India; for example, OSL has been used to date Pleistocene sediments of fluvial and aeolian origin in the valley of the River Luni, India (Jain *et al*., 1998). A number of other applications have contributed to IGCP 449 (Nott *et al*., 2002; Jain *et al*., 2003; Jain & Tandon, 2003; Srivastava *et al*., 2003a, b; Zhang *et al*., 2003).

Uranium series dating: This method requires uranium-bearing deposits within closed systems in which the radiometric material is neither gained nor lost after deposition. The most effective applications to date have been on speleothems and other calcareous precipitates. The method is well suited to dating travertines within fluvial sequences, such as those in East Germany, where the method has been used to resolve the ages of the Taubach and Ehringsdorf travertines in the River Ilm terrace sequence (e.g. Mallik *et al*., 2000; Bridgland *et al*., 2004b). Similarly, calcareous concretions at Beeches Pit, West Stow, Suffolk (UK), have provided U-series ages that support attribution of the distinctive N.W. European *Lyrodiscus* molluscan biome to MIS 11 (Preece *et al*., in press). The use of this technique for dating cave deposits has important implications for fluvial and landscape history, since caves can record base-level changes caused by fluvial incision and, being underground, are more likely to survive intact, even after glaciation and other erosive disturbance (e.g. Farrant *et al*., 1995; Ford, 2000; Granger & Anthony, 2001; Granger *et al*., 2001). A promising collaboration between the karst/speleothem and fluvial communities is emerging to jointly progress this line of investigation, which will be promoted during the new project.

Electron spin resonance (ESR) dating: This is a technique suited to calcareous materials such as speleothem, travertine/tufa and fossil shell and tooth enamel. It was used recently to date tufa at the top of the Garonne Formation fluvial sequence of the Somme at St Acheul, type locality of the Acheulian Palaeolithic Industry; the age of this deposit, which is another to contain the *Lyrodiscus* molluscan biome, was calculated as 403 ± 73 ka, confirming the correlation of the St Acheul interglacial with MIS 11 (Antoine & Limondin-Lozouet, 2004).

Potassium-Argon **(^{40}K /^{40}Ar and ^{40}Ar/^{39}Ar)** ***dating***: These techniques are widely applied for the dating of igneous rocks, including lavas and ashes interbedded with fluvial sequences. A key development has been the application of the Cassignol (unspiked) variant of the K/Ar technique to Middle Pleistocene basalts interbedded with fluvial deposits in Turkey (Yurtmen *et al*., 2002; Westaway *et al*., 2003b, 2004a). Comparable work has been undertaken in the Auvergne region of France, where the volcanic rocks are interbedded with terrace deposits of the Allier system and were visited during the FLAG/IGCP 449 2002 meeting at Clermont-Ferrand (Pastre, 2004; IGCP 449 2002 Annual Report, Appendix I). Comparative studies have been undertaken to evaluate the unspiked K/Ar variant against Ar/Ar dating of Late Cenozoic lavas and have shown that the former method, which is quicker and less expensive, produces data with comparable error margins. Further afield, Campbell *et al*. (2001) used the Ar/Ar technique to date tuffs of Andean origin interbedded with sediments of the ancestral Amazon River in SE Peru, providing the first quantitative control on the evolutionary history of the World's largest river system.

Cosmogenic Isotopes: Cosmogenic (^{26}Al, ^{36}Cl and ^{10}Be) dating is based upon the modelling of the production of these isotopes on newly exposed rock/boulder surfaces by cosmic ray bombardment. To date there have been relatively few applications of this technique in fluvial systems (e.g. the Indus: Burbank *et al*., 1996) but they have considerable potential, especially for use in sequences that include strath (erosional) terraces and significant gorges cut into bedrock. A variant of the technique can date recent burial of sediment that was formerly exposed at the Earth's surface, making it particularly valuable for dating sediments transported into caves by fluvial systems (e.g., Granger & Anthony, 2001; Granger *et al*., 2001).

Archaeology

In north-west Europe, where some of the best-known studies of river terrace sequences have been carried out, the fluviatile deposits are also an important repository for Palaeolithic artefacts, from which a record of early human occupation can be reconstructed (much more readily than from rare occurrences of hominid fossils). Indeed, in Britain and on the European continent, river terrace deposits have provided the bulk of the artefact evidence for the presence of Lower Palaeolithic hunter-gatherers (Wymer, 1968, 1988, 1999; Roebroeks & van Kolfshoten, 1995). This is also true of fluvial sequences in the Near East, Middle East, parts of Asia and Africa, although the data from these regions are patchy (e.g. Bar-Yosef, 1998).

IGCP 449 has included an active Palaeolithic working group, led by Sheila Mishra, Deccan College, India (currently in Ethiopia) and Mark White (Durham, UK). During the course of the initial project the main advances have been in Europe, with new discoveries of very early fluvio-estuarine archaeological records in eastern England (N. Ashton & S. Parfitt, work in progress) and the discovery of a fossiliferous tufa at the Acheulian type locality, St Acheul (River Somme), northern France (Antoine & Limondin-Louzouet, 2004). The British Government's Aggregates Levy Sustainability Fund, initiated during the life of IGCP 449, has seen a plethora of new studies of Palaeolithic fluvial archives in southern Britain, since these coincide with the aggregate sources that the levy is designed to mitigate. This, on top of an already healthy statutory developer-funding system for archaeological assessment and rescue ahead of civil engineering and building projects, has led to very significant increases in knowledge of the British fluvial Palaeolithic record since 2000 (IGCP 449 Annual Report, 2003, Appendix Ii). Most recently, a new Clactonian locality has been discovered in association with River Thames tributary deposits along the route of the Channel Tunnel Rail Link, on the outskirts of Swanscombe and <5km from the celebrated Swanscombe Skull Site National Nature Reserve, a former Thames gravel quarry (http://www.oxfordarch.co.uk/pages/ctrlele.htm).

Project 449 Palaeolithic subtheme activity has also been reported from India, Jordan, South Africa, Syria, Turkey and the United Arab Emirates (IGCP 449 Annual Reports: 2001, Appendix Ei; 2002, Appendix Ci; 2003 Appendix Ii). It is hoped that these achievements can be matched in other areas during the follow-up project.

Landscape and crustal evolution

Already identified as a newly emphasized component of the follow-up project, as recognized within its title, the provision of innovative data on landscape evolution has perhaps been the most impressive achievement of IGCP 449. A number of patterns of crustal and landscape evolution that have emerged from the initial data collection will be targeted for examination and testing during the follow up project, as follows:

- Many regions show transitions from marine to terrestrial environments back in the Miocene, related both to global sea-level change and the initiation of uplift. Such records include those from the Andean foreland basin (e.g., Hoorn *et al.*, 1995, SE

Turkey (e.g., Westaway & Arger, 1996; Derman, 1999), the Paratethys/Alpine Foreland basin (e.g., Pecsi, 1973; Steininger & Rögl, 1984; Vennemann & Hegner, 1998; Kovac *et al*., 2001) and the Murray-Darling, SE Australia (Jones, 2002). A key aim of the new project will be to add to these records and to refine their dating, allowing the synchrony of these key transitions to be tested.

- Allied to the above is the common observation of basin inversion between the Miocene and Quaternary. Typically stacked fluvial sedimentation during the late Tertiary is followed by uplift and fluvial dissection of the basin infill. Examples from IGCP 449 include parts of the Murray-Darling Basin, south-eastern Australia (Jones, 2002), and the Uşak-Güre Basin of western Turkey (Westaway *et al*., 2003b; 2004a; Demir *et al*., 2004).

- Modelling of the results to date from IGCP 449 suggest that there is a strong correlation between measurable parameters observed in fluvial sequences, such as rates of uplift and rates of change of uplift rates, and the thermal state of the crust, quantified by the thickness of the mobile lower-crustal layer. This is particularly clear from fluvial sequences in France, where a systematic effect is observed between the north, along the English Channel, and the Massif Central, where the lower crust is much hotter and the lower-crustal layer is consequently thicker (Westaway, 2004). At the other extreme, in Archaean cratons, which lack any mobile lower-crustal layer, rates of uplift are minimal (Westaway *et al*., 2003a). Further work will investigate this effect both observationally and by numerical modelling but, in order to demonstrate it, accurate control of terrace ages is needed. This line of research is of great potential value in the study of landscape evolution, one of the key themes of the follow-up project.

INTERNET DATABASE

The internet database established under IGCP 449 will be redesigned and greatly extended under the new project. It is anticipated that a change will be made from the provision of summary diagrams as pdfs to fully interactive web pages capable of displaying images to a range of sizes and resolutions. This will allow tagging with captions etc., allowing access for search engines. Material will be added only after publication or acceptance for publication, with full details of published sources being provided.

The intention is to include in the database information such as sediment types, height of sedimentary units above sea-level, downstream gradient, relation to adjacent non-fluviatile deposits, palaeontological data, archaeological content, fossil soils and any dating evidence. It is anticipated that summary tables, idealized transverse sections through terrace staircases and long-profile diagrams and maps will form an important part of the database.

The database resides on the web site of the University of Durham, home institute of co-leader David Bridgland (facility provided at no cost). In late 2004 the Durham site is undergoing a complete reorganization and enhancement. Awaiting completion of this work, which is entirely outside the influence of the project, has precluded updatng of the database in recent months. This will be rectified as soon as the new Durham web site is fully operational, hopefully before the end of 2004. Significant amounts of new material, stemming from project publications during 2003 and 2004, await incorporation.

PRESENT STATE OF KNOWLEDGE AND LEVEL OF ACTIVITY (2004 – the final year of IGCP 449)

Baseline data for the start of the new project is summarized in Table 1. Key elements only will be highlighted here, with a commentary on the potential for obtaining innovative results in the proposed new project.

NW Europe: numerous extensive fluviatile records were well known, even before IGCP 449 (Table 1), mainly in the form of terrace staircases. There are also important buried sequences (e.g. the Lower Rhine, the North Sea basin). Much work was carried out during the lifetime of IGCP 449 and has been published in journal articles, including those in the project-sponsored special issues and edited volumes (*Quaternary International*, 2001 [The response of river systems to climate change]; *Netherlands Journal of Geosciences*, 2003 (Appendix A); *Proceedings of the Geologists' Association*, 2004 (Appendix D); *Quaternaire* 2004 (Appendix C).

Information from this area forms the core of the IGCP 449 internet database, with summary sequences available from, e.g., the Rivers Thames, Solent, Trent, Somme, Seine, Allier/Loire and Maas.

Eastern Europe and the former Soviet Union: numerous records are well established, especially from the Czech Republic, Poland, Russia, the various countries on the Danube and from other Black Sea rivers, having been published previously in German, Russian and/or other languages. Under IGCP 449 several summary publications have appeared in English, notably those by Matoshko *et al*., 2002, 2004; Matoshko, 2004; Meyrick & Schreve, 2002;

Marks & Pavlovskaya, 2003; Alekseev & Drouchits, 2004; Marks, 2004; Patyk Kara & Postolenko, 2004 and Tyráček *et al*., 2004. Information from this area has been entered on the IGCP 449 internet database, with summary sequences available from the Wipper and Ilm (eastern Germany), Vltava (Czech Republic), Vistula (Poland), Dniester (Moldova/Ukraine), Dnieper (Ukraine), Volga (Russia), Don (Russia), Kolyma (Russia) and Lena (Russia). Andrei Motoshko (Ukrainian National Academy of Sciences, Kiev) will be a co-leader of the new project.

Southern Europe: data from southern Europe have accumulated relatively slowly, despite project participation in Spain and Italy. French data is less satisfactory from the south of the country, but there are good records from the Iberian Peninsula, where fluvial deposits are repositories for faunal and archaeological remains (Santonja & Villa, 1990; Agusti *et al*., 2001; Table 1). It is hoped that representation of IGCP 449 at the Florence IGC and within the FLAG meeting in Siena, during September 2004, and then the 449 end-of-project meeting in southern Spain in December 2004, will act as catalysts for the compilation of southern European fluvial archives. The level of Turkish participation has been excellent, providing useful links with the Middle East and Asia (cf. Westaway *et al*., 2003b, 2004a, b; Demir *et al*., 2004). Data also exists from Greece, where an offshore subsiding area in the Gulf of Corinth contains a stack of fluvial sediments (Westaway, 2002c). Again, the new project will lead to the wider dissemination of this data. Material will be added to the internet database as publications appear.

N. Africa: the location of a plenary IGCP 449 meeting in Agadir, Morocco, during 2002 led to a supply of data from North Africa, although only Egypt (the Nile) was represented from Africa outside Morocco (a special issue or collection of papers arising from the Agadir meeting is being compiled for publication in the journal *Géographie Physique et Quaternaire*, comprising articles in French and English and including several papers on Morocco and one on the Nile, as well as several from other countries around the World). A paper on fluvial sequences in Morocco appears in the IGCP 449 special issue of *Proceedings of the Geologists' Association* (Bhiry & Occhietti, 2004). Other North African and circum-Saharan countries remain data vacuums. Material will be added to the internet database as publications appear.

North America: despite project participation in the 16th INQUA Congress in Reno, Nevada, (Session No. 3: 'Fluvial Archives of Environmental Change'), available data on North American fluvial archives are modest in extent. One of the best records is, perhaps surprisingly, from the Yukon River in the extreme north of the continent, which has a terrace sequence extending back into the Tertiary (Froese *et al*., 2000; Duk-Rodkin & Barendregt, 2001; Froese, 2002). Sequences from the USA include that of the Susquehanna, on the eastern seaboard (Pazzaglia & Gardner, 1994) and the Ohio (e.g. Jacobson *et al*., 1988). A second useful Canadian sequence comes from the St Lawrence (Clet-Pellerin & Occhietti, 2000). The terraces of the Mississippi system are well known (e.g. Blum & Straffin, 2001). Research on long fluvial sequences is generally less well developed than in Europe (Table 1).

Middle East (Israel, Levant, Mesopotamia): building on pioneering work in Iraq by Czech project participant Jaroslav Tyráček (1987), significant new data has been accumulated from the Middle East during the lifetime of IGCP449. One such contribution was published in the IGCP 449 special issue of *Current Science* (New Delhi) in 2003, from the Orontes in Syria (Bridgland *et al*., 2003). Other data come from a variety of Turkish rivers in the Levantine part of that country (Demir *et al*., 2004) and, yet to be published, new work on the Euphrates and Tigris in both Turkey and Syria. In Syria the work has been largely inspired by archaeological (Palaeolithic) interests in the fluvial sequence (see IGCP 449 Annual Reports: 2002, Appendix Ci; 2003, Appendix Ii).

***Asia*:** work in Asia has proved both highly successful and somewhat frustrating during the course of IGCP 449. The success was in India, where a vibrant community became engaged in the project through the joint leadership of Sampat Tandon and the location of the 2nd plenary meeting in that country during December 2001 - a significant success despite difficulties caused by it following so soon after the events in New York on September 11th of that year. This led to publication of an IGCP 449 special issue of *Current Science* (New Delhi) devoted to fluvial studies, mostly (but not exclusively) in India, the best of which have been selected for adding to the project web site (Table 1). Rajiv Sinha, co-organizer of the Indian plenary meeting (at his home university in Kanpur) will take over from Tandon as one of the leaders of the follow-up project. Following the Kanpur (2001) meeting, he has launched a major drilling programme in the alluvial Ganges plain, aimed at building a sound database on the Late Quaternary sequences. So far, more than 700 metres of cores have been collected and are being analysed for sedimentology, magnetic susceptibility and OSL chronology (in collaboration with S.K. Tandon (Delhi) and Martin Gibling (Dalhousie)).

Although China was also represented amongst the IGCP 449 leadership, efforts to organize a meeting there were repeatedly frustrated, the final straw being the 2003 SARS epidemic. China has some of the most extensive fluviatile sequences in the World, often with thick loessic overburden, with interbedded fossil soils, that has been studied extensively (Li, 1991; Porter *et al*., 1992). Its principal river systems, the Yellow (Huanghe) and Yangtze, flow from the Tibetan plateau to the East China Sea. Just east of tibet, near the city of Linxia, the Yellow River has formed a staircase of terraces, teach overlain by loess, that records ~500 m of incision since the earliest Pleistocene (Li et al., 1997). Further upstream, within Tibet itself, where more uplift is expected, the Yellow River is instead very young, its throughgoing drainage having superseded a former network of interconnected lake basins in the Late Pleistocene (e.g., Shackleton and Chang, 1988; Li, 1991; Fielding *et al*., 1994). However, sediments from these long-lasting palaeolakes may well provide information on long-timescale climate change associated with the uplift of Tibet. East of Tibet, in the 'Three Gorges' region (now being flooded by one of the world's largest hydroelectric / irrigation reservoirs) fluvial deposits of the Yangtze are found up to ~1250 m above present river level, these being claimed as the highest known river terrace in the World (Yang 2004; IGCP 449 2003 Annual Report, Appendix Hviii). A Chinese meeting will be given high priority early in the course of the follow-up project.

Far East**:** outside China relatively little is known of records from the Far East, although Sugai (1993) and Kim (2001) have published sequences from Japan and Korea respectively. Takeyuki Ueki has recently reported on fluvial records from Japan (Ueki 2001; Ueki & Yamamoto, 2003). A karstic record related to fluvial base level is known from Borneo (Farrant *et al*., 1995). This is a region that has thus far yielded minimal data and so will be prioritized during the follow-up project.

Australasia**:** in 2002 a project meeting took place in Australia, based in the University of Wollongong and including a 10 day field programme in the Lake Eyre inland basin and adjacent east coast/south coast catchments. Although Australia has been predominantly (and increasingly) arid during the late Quaternary, there are important fluvial archives in the Murray - Darling Basin, the filling of which began in the Early Cenozoic (Jones, 2002). East coast rivers such as the Shoalhaven also have excellent sedimentation histories (Nott *et al*., 2002) and important fluvial sequences, interbedded with aeolian and lacustrine sediments, are also known from the Lake Eyre region and its main feeders such as Cooper's Creek (Nanson *et al*., 1999). A review of SE coastal rivers was also undertaken under IGCP 449 (Nanson *et al*., 2003). A further significant project contribution has come from Papua New Guinea, where rivers in the Finisterre and Sarawaget mountains show evidence of rapid uplift (Findlay, R.H. submitted [IGCP Special Issue, *Geographie Physique et Quaternaire*]). Although significant records are reported (e.g. Bull, 1991), information from New Zealand has yet to be added to the project data banks and will be a prime target for the new project. However, much of New Zealand was recently glaciated and very high erosion rates have been reported, both of which may limit the potential for preservation of long-timescale fluvial sequences.

Sub-Saharan Africa**:** the level of activity in this varied region during the initial project was disappointing. Attempts to initiate new work on the Vaal-Orange sequence were unsuccessful, despite much interest in its archaeological contents (IGCP 449 Annual Reports: 2001,

Appendix Ei; 2002, Appendix Ci; 2003, Appendix Ii). Most research taking place during the lifetime of IGCP 449 was instigated by foreign workers, such as a Dutch project in Kenya (IGCP 449 2002 Annual Report, Appendix Civ). The long-term stability of the African landscape has led to the preservation of sequences that extend back into the early Neogene (Table 1). The terraces of the Sundays River, eastern South Africa have provided important evidence of uplift history extending back over a comparable time scale (Hattingh & Rust, 1999) but there is uncertainty about the chronology.

South America**:** there was immediate interest in IGCP 449 from workers on mammalian faunas from fluvial sequences in Argentina and Uruguay, with representation at the inaugural meeting in Prague and a paper in the resultant special issue (Ubilla, 2004). Plans for a meeting in Argentina in 2003 foundered because of the economic uncertainties at that time, but could be resurrected for the follow-up project. Meanwhile there was a significant contribution from Brazil, which hosted the 2003 plenary meeting in Belem, with an excursion into Amazonia. The Amazon is the World's largest river system but has been relatively little studied due to difficulties of access and lack of exposure resulting from the dense vegetation cover. An additional problem that became apparent at the 2003 meeting was that there are major disputes between workers concerning both ages and depositional environments of Late Cenozoic sediments (Westaway, in press). Resolution of these disputes will be an urgent priority for the follow-up project. A special publication on the evolution of Amazonia is being prepared and will include IGCP 449 contributions, which will then be added to the internet database. Co-organizer of the Brazilian IGCP 449 meeting, Edgardo Latrubesse, will be a joint leader of the follow-up project. He and Rajiv Sinha, also a proposed joint project leader, have edited a special issue of *Geomorphology* devoted to tropical rivers, which is identified as a contribution to IGCP 449 (publication imminent – see Appendix G)

OUTPUT AND DISSEMINATION OF RESULTS

The compiled information will be added to the established database, the future evolution of which will be determined early in the project. Material will only be posted on the database site once it has been published or accepted for publication, with full reference linkage supplied. It is likely that the meetings organized a part of the project will themselves lead to further publication of edited volumes or special issues of journals, following the pattern already established during the course of IGCP 449 (see Appendices A-G).

WIDER CONTEXT

Prior to IGCP 449, no previous project has attempted global correlation of the sedimentary records provided by the World's rivers. Several regionally and/or thematically based IGCP projects had paid considerable attention to such deposits, however, notably **IGCP 73/1/24** (Quaternary Glaciations of the Northern Hemisphere), **IGCP 378** (Circumalpine Quaternary correlations) and **IGCP 396** (Continental Shelves in the Quaternary). IGCP 449 activities have overlapped to a certain extent with those of **IGCP 437** (Coastal Environmental Change during Sea-level Highstands), including representation of 449 at UK 437 meetings in London (2000), Durham (2001) and Southampton (2003), as well as vice versa at the 449 meeting in Wollongong, Australia, July 2002. Cooperation and interaction is anticipated between the proposed follow-up project and new project **IGCP 495 (**Quaternary Land-Ocean Interactions: Driving Mechanisms and Coastal Responses), which is co-led by Anthony Long, a colleague of David Bridgland in Durham. Another proposed IGCP project, entitled 'Fluvial Palaeo-Systems: Evolution and Mineral Deposits', has a potential minor overlap with this proposed project. The former will, however, mainly concentrate on mineral deposits related to palaeodrainage systems, including Pre-Cenozoic ones. IGCP 449 contributor Natalia Patyk-Kara will provide a link, ensuring cooperation between the two projects.

The proposed follow-up project will, like IGCP 449, form an integral part of the activities of the Fluvial Archives Group (FLAG), through which outputs from this project will feed directly into closely allied research initiatives linked to INQUA and the IGU.

EXCHANGE OF SCIENCE

Expertise on the study of fluvial sequences and on related areas of research that feed into the project, such as geochronological methodology, will be disseminated, by means of the project, to areas where it is at present less well developed. This will be carried out by means of participation in working groups and by holding workshops on key methodological topics at project meetings, in particular on the collection and recording of field evidence, GIS and dating methods. Such workshops were a component part of IGCP 449 meetings, such as in Prague (2001), where there was a workshop on database protocols, and Kanpur (2001), where there was a workshop on geochronological methods. It is hoped that the project will also serve to encourage exchange visits between participants and other scientific links.

BENEFIT TO SOCIETY

In addition to furthering academic research and promoting the exchange of ideas and scientific methods (see above), a number of aspects of the project will be of potential value to society. These range from provision of enhanced information on river activity, of value to water authorities and river management bodies, to benefits to companies engaged in wealth creating enterprises such as mineral extraction from fluvial sediments. Some of these will be identified below.

Environmental change

The Late Cenozoic records to be researched and collected during the course of the proposed project will provide a database of environmental change during the Late Cenozoic and, especially, the Quaternary. This has been a period of fluctuating climate, which has resulted in considerable environmental instability. There is increasing evidence that human activities are causing atmospheric changes that may lead to future climatic change over a very brief timescale, in geological terms; concern about this has significantly increased during the life of the initial project. A possible connection with increased incidence of flooding by rivers (see the section below) is just one of the issues. The proposed project will provide useful data on past changes that will help scientists to make accurate predictions about the future. The project will also be linked to several other initiatives currently running/planned by the participants. For example, Rajiv Sinha (Kanpur, India) is running a project titled “Tracking Environmental Change and Human Impact in The Ganga Plains” funded by the Ministry of Human Resources and Development, Government of India. The results of such projects will generate valuable database input for the proposed IGCP project.

River management and water supply

The database of fluvial sedimentary records will represent an archive of river activity and its relation to forcing factors such as climate, vegetation and tectonic activity. Some of the higher-resolution studies, in particular, will provide detailed information on the extent and rapidity of changes in the river environment and of fluvial activity. These will be of value to those responsible for managing the World’s rivers, or for providing advice for those living in close proximity to rivers, many of whom will depend on the river for their livelihood. Closely related to living in harmony with rivers is their use for water supply, for drinking, for industry and for crop irrigation. Those managing water extraction from rivers again require the best possible knowledge and understanding of river activity, knowledge that the proposed project will enhance. In general, it is clear that a better understanding of what rivers have done in the past will lead to more informed prediction of what they might do in the future.

This aspect of societal benefit was brought home to participants in IGCP 449 by the much publicized flooding of Prague by the River Vltava during the summer (August 2002) following the Inaugural Project Meeting there. Several studies carried out in India during the tenure of the IGCP 449 project have demonstrated the utility of geomorphological approaches for furthering understanding of avulsion related processes and flood hazards of the Indian river basins using a case study of the Baghmati river, north Bihar. Very effective use was made of a large number of tools, particularly remote sensing, including several image processing techniques. The resulting publications have provided new insights on avulsion processes and development of anabranching stretches in river systems of humid settings (Jain & Sinha, 2003b, 2004). The publications arising out of this work constitute a definite addition to knowledge in the field of flood studies that is of critical importance in the Indian context (Jain & Sinha, 2003c, d). Another important issue in India and neighbouring countries is arsenic poisoning of water supplies, which was also addressed in the publication from the Indian meeting (Appendix B). As well as considering longer timescales, the June 2003 IGCP 449 field trip to the Amazon addressed environmental management issues related to river systems (e.g., flooding, landsliding caused by bank collapse; cf. Latrubesse *et al*., 2003). It is intended that the follow-up project will include similar ventures in other river systems.

The commercial value of river sediments

The mineral extraction industry exploits river deposits in many parts of the World. This exploitation ranges from low value bulk extraction of sand and gravel by the aggregate industry to the procuring of high value secondary (placer) minerals from fluvial sediments. The latter has given rise to data contributing to IGCP 449 from Siberian rivers (Patyk-Kara & Postolenko, 2004) and is a key factor in the working of South African fluvial deposits for diamonds (Helgren, 1979; De Wit *et al*., 1997). In the cratonic part of Brazil, extraction of alluvial diamonds has provided extensive information on the complex history of incision and aggradation by the upper reaches of the Paraná (Bibus, 1983), whereas extraction of alluvial gold exposes the deposits of the Madeira, the largest Amazon tributary (Westaway, in press). Data on the distribution of fluvial deposits, their classification by type, age and origin and a better understanding of their emplacement, all of which will be delivered by the proposed project, will be of value to those exploiting such deposits commercially.

Other valuable sediments from fluvial sequences*:* Sediments of non-fluviatile origin that occur in association with alluvial deposits are sometimes of commercial value. These include, amongst others, valley-bottom peats, loessic material overlying fluvial gravels (of use for brick-making and as a supply of 'loam') and travertine (a source of lime).

In some cases the alluvial sediments themselves have special qualities and are more valuable than mere sand or aggregate for building. High silica sands are required for glass-making and other industries, whereas other sands may be suitable for use in filter systems. Again, data on distribution and quality of fluvial sediments will assist in these commercial interests.

REFERENCES

Acharyya, S.K. & Basu, P.K. (1993). Toba ash on the Indian subcontinent and its implication for correlation of Late Pleistocene alluvium. *Quaternary Research*, **40**, 10-19.

Adam, K.D., Bloos, G. & Ziegler, R. (1995). Stop 11: Steinheim / Murr, N of Stuttgart - Locality of *Homo steinheimensis*. In: Schirmer, W. (ed.) *Quaternary field trips in Central Europe* (vol. 2). Verlag Dr. Friedrich Pfeil, Munich, 727-728.

Agusti, J., Cabrera, L., Garces, M., Krijgsman, W., Oms, O. & Pares, J.M., (2001). A calibrated mammal scale for the Neogene of western Europe: state of the art. *Earth Science Reviews*, **52**, 247-260.

Alekseev, M.N. (1996). Possible 'Cromerian Complex' equivalent sequences in the Russian Plain. In: Turner, C. (ed.): *The early Middle Pleistocene in Europe*. Balkema, Rotterdam, 273-277.

Alekseev, M.N. & Drouchits, V.A. (2004). Quaternary fluvial sediments; structure, distribution and genetic conditions in the Russian Arctic and Subarctic. *Proceedings of the Geologists' Association*, **115**, in press.

Allen, L.G. & Gibbard, P.L. (1994). Pleistocene evolution of the Solent River of southern England. *Quaternary Science Reviews*, **12**, 503-528.

Allen, L.G., Gibbard, P.L., Petit, M.E., Preece, R.C. & Robinson, J.E. (1996). Late Pleistocene interglacial deposits at Pennington Marshes, Lymington, Hampshire, Southern England. *Proceedings of the Geologists' Association*, **107**, 39-50.

Alonso P., Dorronsoro C. & Egido J.A. (2004). Carbonatation in palaeosols formed on terraces of the Tormes river basin (Salamanca, Spain). *Geoderma*, **118**, 261-276.

Angelova, D., Nenov, T. & Spiridonov, H. (1993). The river terraces of the Maritza river in the Quaternery development of the High Thracian lowland. *Reviews of the Bulgarian Geological Society*, **54**, 41-59 (in Bulgarian, abstract in English).

Angelova, D., Ruseva, M., & Tzankov, T. (1991). On the structure and evolution of Karlovo graben. *Geotectonics, Tectonophysics, Geodynamics*, **23**, 26-46 (in Bulgarian with English abstract).

Antoine, P. (1990). *Chronostratigraphie et environnement du palaeolithique du bassin de la Somme*. Publications du CERP no. 2, Université de Sciences et Techniques de Lille, Flandres-Artois.

Antoine, P. (1994). The Somme valley terrace system (northern France): a model of river response to Quaternary climatic variations since 800,000 bp. *Terra Nova*, **6**, 453-464.

Antoine P. & Limondin-Lozouet N. (2004). Identification of MIS 11 Interglacial tufa deposit in the Somme valley (France): new results from the Saint-Acheul fluvial sequence. *Quaternaire*, **15**, 41-52.

Atkinson, T.C., Briffa, K.R. & Coope, G.R. (1987). Seasonal temperatures in Britain during the past 22 000 year, reconstructed using beetle remains. *Nature*, **325**, 587-592.

Auguste, P., Carpentier, G. & Lautridou, J.-P. (2003). La faune mammalienne de la basse-terrasse de la Seine à Cléon (Seine-Maritime, France) : interprétations taphonomiques et biostratigraphiques. *Quaternaire*, **14**, 5-14.

Augustin, L. & 56 others. (2004). Eight glacial cycles from an Antarctic ice core. *Nature*, **429**, 623-628.

Bar-Yosef, O. (1998). Early colonizations and cultural continuities in the Lower Palaeolithic of western Asia. In: Petraglia, M.D. & Korisettar, R. (eds.): *Early Human Behaviour in Global Context*. Routledge, London, 221-279.

Bassinot, F.C., Labeyrie, L.D., Vincent, E., Quidelleur, X., Shackleton, N.J., Berger, A. & Lancelot, Y. (1994). The astronomical theory of climate and the age of the Brunhes-Matuyama magnetic reversal. *Earth and Planetary Science Letters*, 126, 91-108.

Bates, M.R. (1994). Quaternary aminostratigraphy in northwestern France. *Quaternary Science Reviews*, **12**, 793-809.

Becker-Haumann, R. & Sobisch, H.-G. (2002). Die Morphologie mindelzeitlicher Schmelzwasserrinnen des bayerischen Alpenvorlandes modelliert mit GIS-basierter 3d-Modellierungssoftware. - *Terra Nostra*, 6: 42-45, 2 Abb.; Berlin.

Benda, L. (1995) *Das Quartär Deutschlands*. Gebrüder Borntraeger, Berlin.

Benito, G., Gutiérrez, F., Pérez-González, A. & Macado, M.J. (2000). Geomorphological and sedimentological features in Quaternary fluvial systems affected by solution-induced subsidence (Ebro basin, NE-Spain). *Geomorphology*, **33**, 209-224.

Bergeing, J.P. & Gilliard, P. (1997). Geomorphologie des terrasses du fleuve Niger a la latitude du Parc National du W, Niger. *Zeitschrift für Geomorphologie N.F.* **41**, 491-504.

Bhatia, S.B. (2003). Facies, fossils and correlation of late Miocene fluvial sequences of the Himalayan foreland basin. *Current Science* (New Delhi), **84**, 1002-1005.

Bhatt, N. & Bhonde, U.A. (2003). Quaternary fluvial sequences of the south Saurashtra, Western India. *Current Science* (New Delhi), **84**, 1065-1071.

Bhiry, N. & Occhietti, S. (2004). Fluvial sedimentation in a semiarid region: the fan and interfan system of the middle Souss Valley, Morocco. *Proceedings of the Geologists' Association,* **115**, in press.

Bibus, E. (1983). Reliefgenerationen am oberen Paraguai in Mato Grosso (Brasilien). *Zeitschrift für Geomorphologie* N.F. Supplement, **48**, 261-274.

Bibus, E. & Wesler, J. (1995). The middle Neckar as an example of fluviomorphological processes during the Late Quaternary Period. *Zeitschrift für Geomorphologie N.F.* Supplement Band, **100**, 15-26.

Blüberger, G. (1996). *Wie die Donau nachWien kam. Von den Quellen bis zur Hainburger Pforte*. Böhlau Verlag, Vienna. 285pp.

Blum, M.D. & Straffin, E.C. (2001). Fluvial responses to external forcing: Examples from the French Massif Central, the Texas Coastal Plain (USA), the Sahara of Tunisia, and the Lower Mississippi Valley (USA). In: Maddy, D., Macklin, M.G. & Woodward, J. (eds.): *River Basin Sediments Systems: Archives of Environmental Change*. Balkema, Rotterdam, 195-228.

Bowen, D.Q., Hughes, S.A., Sykes, G.A. & Miller, G.M. (1989). Land-sea correlations in the Pleistocene based on isoleucine epimerization in non-marine molluscs. *Nature*, **340**, 49-51.

Bowen D.Q., Richmond, G.M., Fullerton, D.S., Sibrava, V., Fulton, R.J. & Velichko, A.A. (1986). Correlation of Quaternary glaciations in the Northern Hemisphere. *Quaternary Science Reviews*, **5**, 509-510 + loose figures.

Bowen, D.Q., Sykes, G.A., Maddy, D., Bridgland, D.R. & Lewis, S.G. (1995). Aminostratigraphy and amino acid geochronology of English lowland valleys: the Lower Thames in context. In: Bridgland, D.R., Allen, P. & Haggert, B.A. *The Quaternary of the lower reaches of the Thames*, Quaternary Research Association Field Guide, Durham, 61-63.

Braga, J.C., Martín, J.M. & Quesada, C. (2003). Patterns and average rates of Late Neogene – Recent uplift of the Betic Cordillera, SE Spain. *Geomorphology*, **50**, 3-26.

Bridgland, D.R. (1994). *Quaternary of the Thames*. Geological Conservation Review Series 7, Chapman and Hall, London, 440pp.

Bridgland, D.R., (2000). River terrace systems in north-west Europe: an archive of environmental change, uplift and early human occupation. *Quaternary Science Reviews,***19**, 1293-1303.

Bridgland, D.R., (2001). The Pleistocene evolution and Palaeolithic occupation of the Solent River. In: Wenban-Smith, F.F. & Hosfield, R.T. (eds) *Palaeolithic archaeology of the Solent River*. Lithic Studies Society Occasional Paper 7. Lithic Studies Society: London. 15-25.

Bridgland, D.R., (2002). Quaternary fluvial deposition on periodically emergent shelves, with special reference to the shelf around Britain. *Quaternary International*, **92**, 25-34.

Bridgland, D.R. & D'Olier, B. (1995). The Pleistocene evolution of the Thames and Rhine drainage systems in the southern North Sea Basin. In: Preece, R.C. (ed.) *Island Britain: a Quaternary Perspective.* Geological Society of London Special Publication No. 96. 27-45.

Bridgland, D.R., Field, M.H., Holmes, J.A., Mcnabb, J., Preece, R.C., Selby, I, Wymer, J.J., Boreham, S., Irving, B.G., Parfitt, S.A. & Stuart, A.J. (1999). Middle Pleistocene interglacial Thames-Medway deposits at Clacton-on-Sea, England; reconsideration of the biostratigraphical and environmental context of the type Clactonian Palaeolithic industry. *Quaternary Science Reviews*, 18, 109-146.

Bridgland, D.R. & Maddy, D. (2002). Global correlation of long Quaternary fluvial sequences: a review of baseline knowledge and possible methods and criteria for establishing a database. *Geologie en Mijnbouw/Netherlands Journal of Geoscience*, **81**, 265-281.

Bridgland, D.R., Maddy, D. & Bates, M. (2004a). River terrace sequences: templates for Quaternary geochronology and marine-terrestrial correlation. *Journal of Quaternary Science*, **19**, 203-218.

Bridgland, D.R., Philip, G., Westaway, R., & White, M. (2003). A long Quaternary terrace sequence in the Orontes River valley, Syria: a record of uplift and of human occupation. *Current Science* (New Delhi), **84**, 1080-1089.

Bridgland, D.R., Preece, R.C., Roe, H.M., Tipping, R.M., Coope, G.R., Field, M.H., Robinson, J.E., Schreve, D.C. & Crowe, K. (2001). Middle Pleistocene interglacial deposits at Barling, Essex, UK: evidence for a longer chronology for the Thames terrace sequence. *Journal of Quaternary Science*, **16**, 813-840.

Bridgland, D.R. & Schreve, D.C. (2001). River terrace formation in synchrony with long-term climatic fluctuation: examples from southern Britain. In: Maddy, D., Macklin, M. and Woodward, J., *River Basin Sediments Systems: Archives of Environmental Change*. Balkema, Rotterdam, 229-248.

Bridgland, D.R. & Schreve, D.C. (2004). Quaternary lithostratigraphy and mammalian biostratigraphy of the Lower Thames terrace system, south-east England. *Quaternaire*, 15, 29-40.

Bridgland, D.R., Schreve, D.C., Keen, D.H., Meyrick, R. & Westaway, R. (2004b). Biostratigraphical correlation between the late Quaternary sequence of the Thames and key fluvial localities in Central Germany. *Proceedings of the Geologists' Association*, **115**, 125-140.

Bridgland, D.R. & Westaway, R. (in press). Late Cenozoic landscape evolution as evidenced from the fluvial record: a review of data and results from IGCP 449 and its possible palaeoclimatic implications. *Global and Planetary Change*.

Břízová E. (2003). Changes of vegetation and climate in sediments of the Morava River in the Protectes Landscape Area Litovelské Pomoraví. *Geoscience Research Reports for 2002*, 52- 54, Czech Geological Survey, Prague.

Brunnacker, K., Löscher, M., Tillmans, W. & Urban, B. (1982). Correlation of the Quaternary terrace sequence in the lower Rhine valley and northern Alpine foothills of central Europe. *Quaternary Research*, **18**, 152-173.

Bull, W.B. (1991). Geomorphic Responses to Climatic Change. Oxford University Press, New Oxford, 326pp.

Bull, W. B. & Kneupfler, P.L.K. (1987). Adjustments by the Charwell River, New Zealand, to uplift and climatic changes. *Geomorphology*, **1**, 15-32.

Bunbury, J.M., Hall, L., Anderson, G.J. & Stannard, A. (2001). The determination of fault movement history from the interaction of local drainage with volcanic episodes. *Geological Magazine*, **138**, 185-192

Burbank, D.W. *et al*. (1996) Bedrock incision, rock uplift and threshold hillslopes in the northwestern Himalayas. *Nature*, **379**, 505-510

Butzer, K.W., Helgren, D.M., Fock, G.J. & Stuckenrath, R. (1973). Alluvial terraces of the lower Vaal River, South Africa: a reappraisal and reinterpretation. *Journal of Geology,* **81**, 341-362.

Campbell, K.E., Heizler, M., Frailey, C.D., Romero-Pittman, L. & Prothero, D.R. (2001). Upper Cenozoic chronostratigraphy of the southwestern Amazon Basin. *Geology*, **29**, 595-598.

Cione, A.L., Azpelicueta, M. de las M., Bond, M., Carlini, A.A., Casciotta, J.R., Cozzuol, M.A., de la Fuente, M., Gasparini, Z., Goin, F.J., Noriega, J., Scillato-Yané, G.J., Soibelzon, L., Tonni, E.P., Verzi, D. & Vucetich, M.G. (2000). Miocene vertebrates from Entre Ríos Province, eastern Argentina. In: "El Neógeno de Argentina", Aceñolaza, F. G. and Herbst, R. Eds. INSUGEO, Serie Correlación Geológica (Tucumán, Argentina), No. 14, 191-237.

Cione, A.L. & Tonni, E.P. (2001). Correlation of Pliocene to Holocene southern South American and European vertebrate-bearing units. *Bolletino de la Societá Paleontologica Italiana*, **40**, 167-173.

Clet-Pellerin, M. & Occhietti, S. (2000). Pleistocene palynostratigraphy in the St. Lawrence Valley and middle Estuary. *Quaternary International*, **68-71**, 39-57.

Conway, B., McNabb, J. & Ashton, N. (1996). *Excavations at Barnfield Pit, swanscombe, 1968-72*. British Museum, London, occasional paper 94, 266pp.

Corvinus, G. (1998). Lower Palaeolithic occupations in Nepal in relation to South Asia. In: Petraglia, M.D. & Korisettar, R. (eds.): *Early Human Behaviour in Global Context*. Routledge, London, 391-417.

De Mauro, C.A. & Christofoletti, A., (1984). Aspectos fisico-geograficos da Regiao Administrativa de Aracatuba. *Geociencias* (Sao Paulo), **3**, 139-167.

Demir, T., Yeşilnacar, İ. & Westaway, R. (2004). River terrace sequences in Turkey: sources of evidence for lateral variations in regional uplift. *Proceedings of the Geologists' Association*, **115**, in press.

Derman, A.S. (1999). Braided river deposits related to progressive Miocene surface uplift in Kahraman Maraş area, SE Turkey. *Geological Journal*, **34**, 159-174.

De Wit, M.C.J., Ward, J.D., & Jacob, J.R. (1997). *Diamond-bearing deposits of the Vaal-Orange River System*. Field Excursion Guidebook, 6th International Conference on Fluvial Sedimentology, University of Cape Town, **2**, 1-61.

Diaz del Olmo, F. *et al.* (1989). Terrazas pleistocenas del Guadalquivir occidental: geomorfologia, suelos, paleosuelos y secuencia cultural. In: *El Cuaternário en Andalucia occidentale*, AEQUA, Sevilla, 27-31.

Diaz del Olmo, F. *et al.* (1993). Cuaternário y secuencia paleolítica en las terrazas del bajo y medioGuadalquivir: aluvionamientos, coluviones, suelos y paleosuelos. *VI Jornadas de Arqueologia Andaluza.* Junta de Andalucia, Huelva.

Dodonov, A.E., Deviatkin, E.V., Ranov, V.A., Khatib, K., Nseir, H. (1993). The Latamne Formation in the Orontes river valley. In: Sanlaville, P., Besançon, J., Copeland, L., Muhesen, S. (eds.), Le Paléolithique de la vallée moyenne de l'Oronte (Syrie): Peuplement et environnement. *British Archaeological Reports, International Series*, No. 587, 189-194.

Domas, J. (1994). The Late Cenozoic of the Al Ghab Rift, NW Syria. *Antropozoikum*, **21**, 57-73.

Duk-Rodkin, A. & Barendregt, R.W. (2001). Geologic evolution of the Yukon River; implications for placer gold. *Quaternary International*, **82**, 5-31.

Farrant, A.R., Smart, P.L., Whitaker, F. F. & Tarling, D.H. (1995). Long-term Quaternary uplift rates inferred from limestone caves in Sarawak, Malaysia. *Geology*, **23**, 357-360.

Fejfar, O. & Heinrich, W.D. (1983). Arvolicoden-Sukzession und Biostratigraphie des Oberpliozäns und Quatärs in Europe. *Schr. Reihe geol. Wiss.*, **19/20**, 61-109.

Fielding, E., Isacks, B., Barazangi, M., & Duncan, C. (1994). How flat is Tibet? *Geology*, **22**, 163-167.

Fink, J., Koci, A., Kohl, H. & Pevzner, M.A. (1979). Palaeomagnetic research in the northern foothills of the Alps and the question of correlation of terraces in the upper reach of the Danube. *IGCP Project 73/1/24 - Quaternary Glaciations in the Northern Hemisphere*, Rep. No. 5, 108-116.

Fisk, H.N. (1951). Loess and Quaternary geology of the Lower Mississippi Valley. *Journal of Geology*, **59**, 333-356.

Ford, T.D. (2000). Vein cavities; an early stage in the evolution of the Castleton caves, Derbyshire, UK. *Cave and Karst Science*, **27**, 5-14.

Froese, D.G. (2002). Eastern Beringian paleoclimate from fluvial and eolian deposits, Plio-Pleistocene middle Yukon River, central Yukon and Alaska. Unpublished PhD thesis, University of Calgary, Canada.

Froese, D.G.. Barendregt, R.W., Enkin, R.J. & Baker, J., (2000). Paleomagnetism of late Cenozoic terraces of the lower Klondike valley, Yukon: Evidence for multiple late Pliocene-early Pleistocene glaciations. *Canadian Journal of Earth Science* , **37**, 863-877.

Gabunia, L. & Vekua, A. (1995). A Plio-Pleistocene hominid from Dmansi, east Georgia, Caucasus. *Nature*, **373**, 509-512.

Galabov, Z. (1982). *Geography of Bulgaria. Physical Geography*. Bulgarian Academy of Sciences, Sofia. 513 pp..

Gibbard, P.L. (1985). *The Pleistocene history of the Middle Thames Valley*. Cambridge University Press, 155pp.

Gibbard, P.L. (1994). *Pleistocene History of the Lower Thames Valley*. Cambridge University Press, 229pp.

Gibling, M.R. Tandon, S.K., Sinha, R. & Jain, M. (in press). Modern interfluves and their expression in the late Quaternary record of the southern Gangetic plains. *Journal of Sedimentary Research*.

Giles Pancheco, F., Santiago, A., Gutiérrez, J.M., Mata, E. & Aguilera, L. (1989). El poblamiento paleolítico en el valle del rio Gadalete. In: *El Cuaternário en Andalucia occidentale*, AEQUA, Sevilla, 43-57.

Granger, D.E. & Anthony, D.M. (2001). The influence of climate change and river incision on cave development in the unglaciated Ohio River basin. *Geological Society of America, Abstracts with Programs, 2001 annual meeting*, 33, no. 6, 341.

Granger, D.E., Fabel, D. & Palmer, A.N. (2001). Pliocene-Pleistocene incision of the Green River, Kentucky, determined from radioactive decay of cosmogenic ^{26}Al and ^{10}Be in Mammoth Cave sediments. *Geological Society of America Bulletin*, **113**, 825-836.

Griffiths, H.I. (2001). Ostracod evolution and extinction - its biostratigraphic value in the European Quaternary. *Quaternary Science Reviews*, **20**, 1743-1751.

Halouzka, R. & Minarikova, D. (1977). Stratigraphic correlation of Pleistocene deposits of the River Danube in the Vienna and Komarno Basins. *Antropozoikum,* **11**, 7-55.

Harris, J.W.K., Williamson, P.G., Verniers, J., Tappen, M.J., Stewart, K., Helgren, D., de Heinzelin, J., Boaz, N. & Bellomo, R. (1987). Late Pliocene hominid occupation in Central Africa: the setting, context and character of the Senga 5A Site, Zaire. *Journal of Human Evolution*, **16**, 701-728.

Hattingh, J. & Rust, I.C. (1999). Drainage evolution and morphological development of the Late Cenozoic Sundays River, South Africa. In: Miller, A.J. and Gupta, A. *Varieties of Fluvial Form*, Wiley, Chichester, 145-166.

Hedburg, H.D. (1976). International stratigraphic guide. Wiley & Sons, New York, 200pp

Helgren, D.M. (1978). Acheulian settlement along the lower Vaal River, South Africa. *Journal of Archaeological Science*, **5**, 39-60.

Helgren, D.M. (1979). *River of diamonds: an alluvial history of the lower Vaal basin*. University of Chicago, Department of Geography Research Paper 185.

Hoorn, C. (1993). Miocene incursions and the influence of Andean tectonics on the Miocene depositional history of northwestern Amazonia: results of a palynostratigraphic study. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **105**, 267-309.

Hoorn, C. (1994a). Fluvial palaeoenvironments in the Amazonas Basin (Early Miocene – early Middle Miocene, Colombia). *Palaeogeography, Palaeoclimatology, Palaeoecology*, **109**, 1-54.

Hoorn, C. (1994b). An environmental reconstruction of the palaeo-Amazon river system (Middle-Late Miocene, NW Amazonia). *Palaeogeography, Palaeoclimatology, Palaeoecology*, **112**, 187-238.

Hoorn, C., Guerrero, J., Sarmiento, G.A. & Lorente, M.A. (1995). Andean tectonics as a cause for changing drainage patterns in Miocene northern South America. *Geology*, **23**, 237-240.

Horacek, I. (1990). On the context of Quaternary Arvicolid evolution: changes in community development. *International Symposium on the Evolution, Phylogeny and Biostratigraphy of the Arvicolids.* 201-222.

Horacek, I. & Lozek, V. (1988). Paleozoology and the Mid-European Quaternary past: scope of approach and selected results. *Rozpr. Cs. Akad. Ved.R. mat. prir. Ved.*, **98**, 1-102.

Howell, F.C., Haesaerts, P. & de Heinzelin, J. (1988). Depositional environments, archaeological occurrences and hominids from Members E and F of the Shungura Formation (Omo Basin, Ethiopia). *Journal of Human Evolution*, **16**, 665-700.

Huntley, D.J., Godfrey-Smith, D.I. & Thewalt, M.L.W. (1985). Optical dating of sediments. *Nature* **313**, 105-197.

Iriondo, M. (1980). El Cuaternario de Entre Rios. *Revista de la Asociacion de Ciencias Naturales del Litoral*, **11**, 125-141.

Jacobson, R.B., Elston, D.P. & Heaton, J.W. (1988). Stratigraphy and magnetic polarity of the high terrace remnants in the upper Ohio and Monongahela rivers in West Virginia, Pennsylvania, and Ohio. *Quaternary Research*, **29**, 216-232.

Jain, M., Botter-Jensen, L. & Singhvi, A. K. (2003). Dose evaluation using multiple-aliquot quartz OSL: test of methods and a new protocol for improved accuracy and precision. *Radiation Measurements*, **37**, 67-80.

Jain, M., Tandon S.K., Bhatt, S.C., Singhvi, A.K. & Mishra, S. (1999). Alluvial and aeolian sequences along the River Luni, Barmer District: physical stratigraphy and feasibility of luminescence chronology methods. *Memoir Geological Society of India*, No 42, 273-295.

Jain, M., Woodcock, N.H. & Tandon S.K. (1998). Neotectonics of western India: evidence from deformed Quaternary fluvial sequences, Mahi River, Gujarat. *Journal of the Geological Society, London*, **155**, 897-901.

Jain, V. & Sinha, R. (2003a). River systems of the Ganga plains and their comparison with Siwaliks: a review, *Current Science* (New Delhi), **84**, 1025-1033.

Jain V. & Sinha, R. (2003b) Hyperavulsive-anabranching Baghmati river system, north Bihar plains, eastern India, *Zeitschrift für Geomorphologie*, **47**/1, 101-116.

Jain, V. & Sinha, R. (2003c) Derivation of Unit Hydrograph from GIUH analysis for a Himalayan river. *Water Resources Management*, **17**, 355-375.

Jain, V. & Sinha, R. (2003d) Geomorphological manifestations of the flood hazard: a remote sensing based approach. *Geocarto Internationa*l, **18** (4), 51-60.

Jain, V. & Sinha, R. (2004) Fluvial dynamics of an anabranching river system in Himalayan foreland basin, north Bihar plains, India, *Geomorphology*, **60**, 147-170

Jain, M. & Tandon, S.K. (2003). Quaternary alluvial stratigraphy and palaeoclimatic reconstruction at the Thar margin. *Current Science* (New Delhi), **84**, 1369-1369.

Jones, B.G. (2002). In: Tooth, S., Nanson, G.C. & Jones, B.G., *A field guide for physical environments in eastern Central Australia.* School of Geosciences, University of Wollongong, New South Wales [published in association with the FLAG/IGCP 449 meeting].

Kaandorp, R., Wesselingh, F. & Vonhof, H. (2004). Ecological implications from geochemical records of Miocene western Amazonian bivalves. *Journal of South American Earth Sciences*, in press.

Keen. D.H. (1990). Significance of the record provided by Pleistocene fluvial deposits and their included molluscan faunas for palaeoenvironmental reconstruction and stratigraphy: case study from the English Midlands. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **80**, 25-34.

Keen. D.H. (2001). Towards a late Middle Pleistocene non-marine molluscan biostratigraphy for the British Isles. *Quaternary Science Reviews*, **20**, 1657-1665.

Kim, J.Y. (2001).Quaternary geology and assessment of aggregate resources of Korea for the national industrial resources exploration and development. *Quaternary International*, **82**, 87-100.

Klammer, G. (1971). Über plio-pleistozäne Terrassen und ihre Sedimente im unteren Amazonasgebiet. *Zeitschrift für Geomorphologie*, **15**, 62-106.

Korisettar, R. & Rajaguru, S.N. (1998). Quaternary stratigraphy, palaeoclimate and the Lower Palaeolithic of India. In: Petraglia, M.D. & Korisettar, R. (eds.): *Early Human Behaviour in Global Context*, Routledge, London, 304-342.

Kovac, M.; Nagymarosy, A. & Holcova, K. (2001). Paleogeography, paleoecology and eustacy; Miocene 3rd order cycles of relative sea-level changes in the Western Carpathian - North Pannonian basins. *Acta Geologica Hungarica*, **44**, 1-45.

Kovanda, J., Smolikova, L. & Horacek, I. (1995). New data on four classic loess sections in Lower Austria. *Sbor. geol. Ved. Antropoziokum*, **22**, 63-85.

Kroonenburg, S., Pessoa, M.R., Silvestre L.A.L. & Pastana, J.M.D.N. (1981). Ignimbritas Pliopleistocenicas en el suroeste del Huila, Colombia y su influencia en el desarrollo morfologico. *Revista CIAF*, **6**, no.1-3, 293-314.

Krzyszkowski, D. & Biernat J. (1998). Terraces of the Bystrzyca river valley, Middle Sudates, and their deformation along the Sudetic Marginal Fault. *Geologia Sudetica*, **31**, 241-258.

Krzyszkowski, D., Przybylski, B. & Badura, J. (1998). Late Cainozoic evolution of the Nysa Kłodzka river system between Kłodzko and Kamieniec Ząbkowicki, Sudates Mts, southwestern Poland. *Geologia Sudetica*, **31**, 133-155.

Krzyszkowski, D., Przybylski, B. & Badura, J. (2000). The role of neotectonics and glaciations along the Nysa-Klodzka River in the Sudeten Mountains (southwestern Poland). *Geomorphology*, **33**, 149-166.

Kukla, G.J. (1975). Loess stratigraphy of Central Europe. *In:* Butzer, K.W. and Isaac, G.L. (eds) *After the Australopithecines: Stratigraphy, Ecology and Culture Change in the Middle Pleistocene*. Mouton, The Hague. 99-188.

Kukla, G.J. (1977). Pleistocene land-sea correlations. I. Europe. *Earth Science Reviews*, **13**, 307-374.

Kumar, R., Ghosh, S.K. & Sangode, S. (2003). Mio-Pliocene sedimentation history the northwestern part of the Himalayan foreland basin, India. *Current Science* (New Delhi), **84**, 1006-1013.

Latrubesse, E., Aquino, S. & Bayer, M. (2003). Rio Branco city: geomorphological risks and environmental quality: applying the ELANEM methodology. In: Latrubesse, E., Stevaux, J. (Eds.), *GLOCOPH and IGCP 449 Field Conference Guide – Amazon, 2003.* Federal University of Goias Press, Goiania, Brazil, 51-62.

Latrubesse, E., Bocquentin, J., Santos, J. & Ramonell, C.R. (1997). Paleoenvironmental model for the Late Cenozoic of southwestern Amazonia: paleontology and geology. *Acta Amazonica*, **27**, 103-118.

Lautridou, J.P., Monnier, J.L., Morzadec-Kerfourn, M.T., Sommé, J. & Tuffreau, A. (1983). Les subdivisions du Pleistocne de la France septentrionale: stratigraphie et paleolithique. In: Billards, O., Conchon, O. & Shotton, F.W. (eds) *Quaternary glaciations in the Northern Hemisphere*. *IGCP Project 73-1-24. Report No. 9, Unesco International Geological Correlation Programme*, Paris. 148-170.

Lautridou, J.-P., Auffret, J.-P., Baltzer, A., Clet, M., Lécolle, F., Lefebvre, D., Lericolais, G., Roblin-Jouve, A., Balescu, S., Carpentier, G., Descombes, J.-C., Occhietti, S. & Rousseau, D.-D. (1999). The river Seine, the river Manche. *Bulletin de la Société Géologique de France*, **170**, 545- 558 (in French with English summary).

Leng, J. (1998). Early Palaeolithic quartz industries in China. In: Petraglia, M.D. & Korisettar, R. (eds.): *Early Human Behaviour in Global Context*, Routledge, London, 418-436.

Lericolais G., Auffret J.P. & Bourillet J.F. (1997). *Evolution plio-quaternaire du fleuve Manche: Stratigraphie et Géomorphologie de la confluence de la Paléo-Somme et de la Paléo-Seine*. Academie de Sciences de France, Montpellier: 23pp.

Li, J. (1991). The environmental effects of the uplift of the Qinghai-Xizang Plateau. *Quaternary Science Reviews*, **10**, 479-483.

Li, J. & 13 others (1997). Magnetostratigraphic dating of river terraces: Rapid and intermittent incision by the Yellow River of the northeastern margin of the Tibetan Plateau during the Quaternary. *Journal of Geophysical Research,* **102**, 10121-10132.

Lozek, V. (1964a). Quartärmollusken der Tschechoslowakei. *Rozpr. Ustr. Ust. geol.*, **31**, 1-347.

Lozek, V. (1964b). Neue Mollusken aus dem Altpleistozän Mittleeuropas. *Arch. Molluskenkunde*, **93** (5/6), 193-199.

McBrearty, S. (1999). The archaeology of the Kapthurin Formation. In Andrews, P. & Banham, P. (eds.): *Late Cenozoic Environments and Hominid Evolution: a tribute to Bill Bishop*. Geological Society, London, 143-156.

Maddy, D. (1997). Uplift-driven valley incision and river terrace formation in southern England. *Journal of Quaternary Science*, **12**, 539-545.

Maddy, D. (2002). An evaluation of climate, crustal movement and base level controls on the Middle-Late Pleistocene development of the River Severn, UK. *Geologie en Mijnbouw/Netherlands Journal of Geoscience*, **81**, 329-338.

Maddy, D., Bridgland, D.R. & Green, C.P. (2000). Crustal uplift in southern England; evidence from the river terrace records. *Geomorphology*, **33**, 167-181.

Maddy, D., Green, C.P., Lewis, S.G. & Bowen, D.Q. (1995). Pleistocene Geology of the Lower Severn Valley. *Quaternary Science Reviews*, **14**, 209-222.

Maddy, D., Keen, D.H., Bridgland, D.R. & Green, C.P. (1991). A revised model for the Pleistocene development of the River Avon, Warwickshire. *Journal of the Geological Society of London*, **148**, 473-484.

Maddy, D., Macklin, M. & Woodward, J. Eds (2001). *River Basin Sediments Systems: Archives of Environmental Change*. Balkema, Rotterdam.

Mallik, R., Frank, N., Mangini, A. & Wagner, G.A. (2000). Anwendung der Uranreihen-Microprobendatierung an quartären Travertinvorkommen Thüringens. *Praehistoria Thuringica*, **4**, 95-100.

Mangerud, J. (1991). The Last Interglacial/Glacial cycle in northern Europe. In: Shane, L.C.K. and Cushing, E.J. *Quaternary Landscapes*. Bellhaven Press, London, 38-75.

Mania, D. (1995). The earliest occupation of Europe: the Elbe-Saala region (Germany). In: Roebroeks, W. and Van Kolfschoten, T. *The Earliest Occupation of Europe.* University of Leiden, the Netherlands, 85-101.

Markova A.K. & Mihailescu C.D. (1994). Correlation of Pleistocene Marine and ContinentalDeposits from the Northwestern Black Sea Region. *Stratigraphy and Geological Correlation*. Vol. **2**, Nr.4. Moscow, 87-95.

Marks, L. (2004). Middle and Late Peistocene fluvial systems in central Poland. Proceedings of the Geologists' Association, **115**, 175-182.

Marks, L. & Pavlovskaya, I. (2003). The Holsteinian Interglacial river network of mid-eastern Poland and western Belarus. *Boreas*, **32**, 337-346.

Mather, A.E., Sliva, P.G., Goy, J.L., Harvey, A,M. & Zazo, C. (1995). Tectonics versus climate: an example from late Quaternary aggradational and dissectinal sequences of the Mula basin, southeast Spain. In: Lewin, J., Macklin, M.G. and Woodward, J.C. (eds) *Mediterranean Quaternary river environments*. Balkema, Rotterdam, 77-87.

Mather, A.E. & Stokes, M., 2003. Long-term landscape development in southern Spain. *Geomorphology*, **50**, 1-2.

Matoshko, A. (2004). Evolution of the fluvial system of the Prypiat, Desna and Dnieper during the late Middle-Late Pleistocene. *Quaternaire*, **15**, 117-128.

Matoshko, A., Gozhik, P. & Ivchenko, A. (2002). The fluvial archive of the Middle and Lower Dnieper (a review). *Geologie en Mijnbouw/Netherlands Journal of Geoscience*, **81**, 339-355.

Matoshko, A.V., Gozhik, P. & Danukalova, G. (2004). Key Late Cenozoic fluvial archives in the central and southern part of the East European Plain (a review). *Proceedings of the Geologists' Association*, **115**, 141-173.

Merritts, D.J., Vincent, K.R. & Wohl, E.E. (1994). Long river profiles, tectonism, and eustasy: a guide to interpreting fluvial terraces. *Journal of Geophysical Research*, **99**, 14031-14050.

Meyrick, R.A. & Schreve, D.C. (2002). *The Quaternary of Central Germany (Thuringia & Surroundings)*. Field Guide, Quaternary Research Association, London, 59-78.

Miller, G.H., Hollin, J.T. & Andrews, J. (1979). Aminostratigraphy of UK Pleistocene deposits. *Nature*, **281**, 539-543.

Mishra, S. (1991). Prehistoric and Quaternary studies at Nevasa: the last forty years. *Memoirs of the Geological Society of India*, No 32, 324-332.

Mishra, S. (1992). The age of the Acheulian in India: new evidence. *Current Anthropology*, **33**, 325-328.

Mishra, S. (1994). The South Asian Lower Palaeolithic. *Man and Environment*, **19**, 57-72.

MME, (2000). Zoneamento ecológico-econômico da região fronteiriça Brasil-Bolívia, mapa geomorfológico integrado, 1:500,000 scale, NW part, sheet 3a. Ministério de Minas e Energia, Serviço Geológico do Brasil, Brasilia.

Nádor, A., Lantos, M. & Thamó-Bozsó, E. (2003). Milankovitch-scale multi-proxy records for the fluvial sediments of the last 2.6 Ma from the Pannonian Basin, Hungary. *Quaternary Science Reviews*, **22**, 2157-2175.

Nanson, G.C., Coleman, M. & Price, D.M. (1999). Alluvial and aeolian evidence for major drainage disruption and changes in wind direction during the last full glacial cycle in central Australia. *Book of Abstracts, XV INQUA Congress, Durban, South Africa*, 130-131.

Nanson, G. C., Cohen, T.J., Doyle C.J. & Price, D.M. (2003). Alluvial evidence of major Late-Quaternary climate and flow-regime changes on the coastal rivers of New South Wales, Australia. In K.J Gregory and G. Benito (Eds), *Palaeohydrology: Understanding Global Change*, Wiley, Chichester, 233-258.

Nenov, T., Slavov, I. & Stoykov, S. (1972). Pliocene and Quaternary in the Gotse Delchev depression and principal stages in its neotectonic development. *Review of the Bulgarian Geological Society*, **33**, 195-203 (in Bulgarian with English summary).

Niculescu, G.H. (1963). Terasele Teleajenului in zona subcarpatia cu privire speciala cesupra miscarilar neotectonice cua ternare. *Proberma de geografia,* 9, 57-83

Nott, J.; Price, D. & Nanson, G. (2002). Stream response to Quaternary climate change; evidence from the Shoalhaven River catchment, southeastern highlands, temperate Australia. *Quaternary Science Reviews*, **21**, 965-974.

Occhietti, S., Bhiry, N., Rognon. P. & Pichet, P. (1994). Stratigraphie et aminochronologie des formations quaternaires de la vallée moyenne du Souss, Maroc. *Quaternaire*, **5**, 23-34.

Occhietti, S. & Long, B. (1999). Middle to Upper Quaternary facies successions and depositional systems in the St Lawrence Basin. Programme & Abstracts, IGCP 396 4th Annual Conference, Cape Town, South Africa, 28.

Okay N. & Okay A. (2002). Tectonically induced Quaternary drainage diversion in the northeastern Aegean. *Journal of the Geological Society*, **159**, 393-399.

Pastre, J-F. (2004). The Perrier Plateau: a Plio-Pleistocene long fluvial record in the River Allier basin, Massif Central, France. *Quaternaire*, **15**, 87-101.

Pastre, J-F., Defive, E., Gablier, F. & Lageat, Y. (1997). Changements hydrographiques et volcanisme plio-quaternaire dans les bassins de la Loire et de l'Allier (Massif central, France). *Géographie physique et quaternaire*, **51**, 295-314.

Patyk-Kara, N.G. & Postolenko, G.A. (2004). Structure and evolution of the Kolyma river valley: from upper reaches to continental shelf. *Proceedings of the Geologists' Association,* **115**, in press.

Pazzaglia, F.J. & Gardner, T. (1994). Late Cenozoic flexural deformation of the middle U.S. Atlantic passive margin. *Journal of Geophysical Research*, **99**, 12143-12157.

Pecsi, M., (1973). Geomorphological position and absolute age of the lower paleolithic site at Vertesszollos, Hungary. *Foldrajzi Kozlemenyek*, **22**, 109-119.

Penkman, K.E.H., Maddy, D. & Collins, M. (2003). Racemization in a box; does a closed system improve kinetics? *Geological Society of America Abstracts with Programs*, Vol. 35, No. 6, September 2003, p. 273.

Perkins, N.K. & Rhodes, E.J. (1994). Optical dating of fluvial sediments from Tattershall, U.K. *Quaternary Science Reviews* **13**, 517-520.

Petraglia, M.D. (1998). The Lower Palaeolithic of India and its bearing on the Asian record. In: Petraglia, M.D. & Korisettar, R. (eds.): *Early Human Behaviour in Global Context*. Routledge, London, 343-390.

Pike, K. & Godwin, H. (1953). The interglacial at Clacton-on-Sea. *Quarterly Journal of the Geological Society of London*, **108**, 11-22.

Porter, S.C. An, Z. & Zheng, H. (1992). Cyclic Quaternary alluviation and terracing in a nonglaciated drainage basin on the north flank of the Qinling Shan, central China. *Quaternary Research*, **38**, 157-169.

Preece, R.C. (1995). Mollusca from interglacial sediments at three critical sites in the Lower Thames. In: Bridgland, D.R., Allen, P. and Haggart, B.A. (eds) *The Quaternary of the lower reaches of the Thames*. Field Guide, Quaternary Research Association, Durham, 55-60.

Preece, R.C. (1999). Mollusca from the Last interglacial fluvial deposits at Trafalgar Square, London. *Journal of Quaternary Science*, **14**, 77-89.

Preece, R.C. (2001). Molluscan evidence for differentiation of interglacials within the 'Cromerian Complex'. *Quaternary Science Reviews*, **20**, 1643-1656.

Preece, R.C. & Parfitt, S.A. 2000. The Cromer Forest-Bed Formation: new thoughts on an old problem. In: Lewis, S.G., Whiteman, C.A., Preece, R.C. (Eds.). *The Quaternary of Norfolk & Suffolk, Field Guide*. Quaternary Research Association, London, 1-27.

Preece, R.C., Parfitt, S.A., Bridgland, D.R., Lewis, S.G., Candy, I., Griffiths, H.I., Whittaker, J.E. & Gleed-Owen, C. (in press). The Hoxnian (Holsteinian) Interglacial and Palaeolithic site at West Stow, Suffolk, UK: the geological, faunal and dating evidence. *Quaternary Science Reviews.*

Rabeder, G. (1974). Die Kleinäugerfauna des Jungpliozäns von Stranzendorf. *Mitt. Quartärkomm. Österr. Akad. Wiss.,* **1**, 137-139.

Rabeder, G. (1981). Die Arvicoliden (Rodentia, Mammalia) aus dem Pliozän und dem älteren Pleistozän von Niederösterreich. *Beitr. Paläont. Österr.,* **8**, 1-337.

Ramage, J.M., Gardner, T.W. & Sasowsky, I.D. (1998). Early Pleistocene glacial Lake Lesley, West Branch Susquehanna River valley, central Pennsylvania. *Geomorphology*, **22**, 19-37.

Raposo, L. & Santonja, M. (1995). The earliest occupation of Europe: the Iberian Penisula. In: Roebroeks, W. & Van Kolfschoten, T. (eds) *The Earliest Occupation of Europe.* University of Leiden, The Netherlands, 7-25.

Räsänen, M., Neller, R., Salo, J. & Jungner, H. (1992). Recent and ancient fluvial deposition systems in the Amazonian foreland basin, Peru. *Geological Magazine*, **129**, 293-306.

Roebroeks, W. & Van Kolfschoten, T. (eds) (1995). *The Earliest Occupation of Europe.* University of Leiden, The Netherlands, 332pp.

Rohde, P. (1989). Elf pleistozäne Sand-Kies-Terrassen der Weser: Erläuterung eines Gliederungsschemas für das obere Weser-Tal. *Eiszeitalter und Gegenwart*, **39**, 24-56.

Ruegg, G.H.J. (1994). Alluvial architecture of the Quaternary Rhine-Meuse river system in the Netherlands. *Geologie en Mijnbouw,* **72**, 321-330.

Ruddiman, W.F., McIntyre, A., & Raymo, M.E. (1986). Matuyama 41,000-year cycle: North Atlantic Ocean and northern hemisphere ice sheets. *Earth and Planetary Science Letters*, **80**, 117-129.

Said, R. (1993). *The River Nile. Geology, Hydrology and Utilization*. Pergamon Press, Oxford, 320 pp.

Salama, R. (1999) The evolution of the River Nile in Sudan. *Book of Abstracts, XV INQUA Congress, Durban, South Africa*, 155-156.

Sangode, S.J. & Kumar, R. (2003). Magnetostratigraphic Correlation of the Late Cenozoic fluvial sequences from NW Himalaya, India. *Current Science* (New Delhi), **84**, 1014-1024.

Santonja, M., Moissenet & Pérez Gonzales, A. (1992). Cuesta de la Bajada (Teruel). Nuevo sítio Paleolítico inferior. *Bul.del Seminario de Estudios de Arte y Arqueologia*, **58**, 25-45.

Santonja, M. & Pérez Gonzales, A. (1984). Las industrias paleolíticas de La Maya en su âmbito regional. *Excav. Arqueol. en Espanã*, **135**. Ministerio de Cultura, Madrid.

Santonja, M. & Villa, P. (1990). The Lower Paleolithic of Spain and Portugal. *Journal of World Prehistory*, **4**, 45-94.

Sanyal, P., Bhattacharya, S.K., Kumar, R., Ghosh, S.K. & Sangode, S.J. (2004). Mio-Plicene monsoonal record from Himalayan foreland basin and its relation to vegetaional changes. *Paleogeography, Paleoclimatology, Paleoecology*, **205**, 23-41.

Saucier, R.T. (1996). *Geomorphology and Quaternary geologic history of the Lower Mississippi Valley.* U.S. Army Corps of Engineers, Vicksburg, 364 pp.

Schreve, D.C. (2001a). Differentiation of the British late Middle Pleistocene interglacials: the evidence from mammalian biostratigraphy. *Quaternary Science Reviews*, **20**, 1693-1705.

Schreve, D.C. (2001b). Mammalian evidence from fluvial sequences for complex environmental change at the oxygen isotope substage level. *Quaternary International*, **79**, 65-74.

Schreve, D.C. & Bridgland, D.R. (2002a). The Middle Pleistocene hominid site of Bilzingsleben. In: Meyrick, R.A. & Schreve, D.C. *The Quaternary of Central Germany (Thuringia & Surroundings)*. Field Guide, Quaternary Research Association, London, 131-144.

Schreve, D.C. & Bridgland, D.R. (2002b). Correlation of English and German Middle Pleistocene fluvial sequences based on mammalian biostratigraphy. *Geologie en Mijnbouw/Netherlands Journal of Geoscience*, **81**, 357-373.

Schulte, L. (2002). Quaternary Evolution of the Vera and eastern Sorbas Basin (SE Iberian Peninsula). A reconstruction of paleoclimatic fluctuations from morphological and pedological studies. University of Barcelona Press, Barcelona, Spain. 251 pp. (in Spanish with English summary).

Semaw, S., Renne, P. Harris, J.W.K., Feibel, C.S. Bernor, R.L., Fesseha, N. & Mowbray, K. (1997). 2.5 million-year-old stone tools from Gona, Ethiopia. *Nature*, **385**, 333-336.

Shackleton, R.M. & Chang Chengfa, (1988). Cenozoic uplift and deformation of the Tibetan Plateau: the geomorphological evidence, *Philosophical Transactions of the Royal Society of London,* **A327**, 365-377.

Shackleton, N.J. & Opdyke, N.D. (1973). Oxygen Isotope and palaeomagnetic stratigraphy of Equatorial Pacific Core V28-238, Oxygen Isotope temperatures and ice volumes on a 10^5 year - 10^6 year scale. *Quaternary Research*, **3**, 39-55.

Sher, A. V., Giterman, R. Y., Zazhigin, V. S. & Kiselev, S. V. (1977). New data on the Late Cenozoic deposits of the Kolyma Lowland. *Akademie Nauk SSSR Izvesti Seriya Geolozh*, **5**, 69-83 (In Russian).

Singh, I. B., Jaiswal, M., Singhvi, A. K. & Singh, B. K. (2003). Rapid subsidence of western Ganga plain during late Pleistocene: Evidence from optical dating of subsurface samples. *Current Science*, **84**, 451-454.

Sinha R., Madhur Khanna, V., Jain, V. & Tandon S.K. (2002). Mega-geomorphology and sedimentation history in the Ganga-Yamuna Plains, *Current Science*, **82**, 562-566.

Sinha, R., Gibling, M.R., Tandon, S.K., Jain, V. & Dasgupta, A. S. (in press). Quaternary stratigraphy and sedimentology of the Kotra section on the Betwa river, Southern Gangetic plains, Uttar Pradesh. *Journal of the Geological Society of India*.

Srivastava, P., Sharma, M. & Singhvi, A.K. (2003a). Luminescence chronology of incision and channel pattern changes in the river Ganga. *Geomorphology*, **51**, 259-268.

Srivastava, P., Singh, I.B., Sharma, M. & Singhvi, A.K. (2003b). Luminescence chronometry and Late Quaternary geomorphic history of the Ganga Plain, India. *Palaeogeography, Palaeoclimatology, Palaeolecology*, **197**, 15-41.

Starkel, L. (2003). Climatically controlled terraces in uplifting mountain areas. *Quaternary Science Reviews*, **22**, 2189-2198.

Steininger, F.F. & Rögl, F. (1984). Paleogeography and palinspastic reconstruction of the Neogene of the Mediterranean and Paratethys. In: Dixon, J.E., Robertson, A.H.F. (eds), *The Geological Evolution of the eastern Mediterranean*. Geological Society of London, Special Publication 17, 659-668.

Stuart, A.J. & Lister, A,M. (2001). The mammalian faunas of Pakefield/Kessingland and Corton, Suffolk, UK: evidence for a new temperate episode in the British early Middle Pleistocene. *Quaternary Science Reviews*, **20**, 1677-1692

Sugai, T. (1993). River terrace development by concurrent fluvial processes and climatic changes. *Geomorphology*, **6**, 243-252.

Sykes G. A., Collins M. J. and Walton D. I. (1995). The significance of a geochemically isolated (intracrystalline) organic fraction within biominerals. *Organic Geochemistry*, **23**, 1059-1066.

Tandon, S.K., Gibling M.R., Sinha R., Singh V., Ghazanfari P., Dasgupta A., Jain M. & Jain V. (in press). Alluvial valleys of the Gangetic Plains, India: causes and timing of incision. *SEPM Special volume*.

Thomas, G.N. (2001). Late Middle Pleistocene pollen biostratigraphy in Britain: pitfalls and possibilities in the separation of interglacial sequences. *Quaternary Science Reviews*, **20**, 1621-1630.

Tyràcek, J. (1983). River terraces – important paleoclimatic indicator. In: Billards, O., Conchon, O. & Shotton, F.W. (eds) *Quaternary glaciations in the Northern Hemisphere*. IGCP Project 73-1-24. Report No. 9, Unesco International Geological Correlation Programme, Paris. 34-41.

Tyràcek, J. (1987). Terraces of the Euphrates River. *Sbornik geologickych ved*, 18, 185-202.

Tyràcek, J. (1995). Stratigraphy of the Ohre River terraces in the Most Basin. *Sbornik geologickych ved*, 22, 1-157.

Tyráček, J. (2001a). Upper Cenozoic fluvial history in the Bohemian Massif. *Quaternary International*, **79**, 37-53.

Tyráček, J. (2001b). *Quaternary of the Mělník Area: IGCP 449 Excursion Guide*. Czech Geological Survey, Prague, ISBN 80-7075-518-0, 17 pp.

Tyrácek, J., Westaway R. & Bridgland, D.R. (2004). River terraces of the Vltava and Labe (Elbe) system in the Bohemian Massif, Czech Republic. *Proceedings of the Geologists' Association*, **115**, 101-124.

Tzankov, T., Angelova, D., Nakov, R., Burchfiel, B.C. & Royden, L.H. (1996). The Sub-Balkan graben system of central Bulgaria. *Basin Research*, **8**, 125-142.

Tzedakis, P.C. and Bennett, K.D. (1996). Interglacial vegetation succession: a view from southern Europe. *Quaternary Science Reviews,* **14**, 967-982.

Tzedakis, P.C., Andrieu, V., De Beaulieu, J-L., Crowhurst, S., Follieri, M., Hooghiemstra, H., Magri, D., Reille, M., Sadori, L., Shackleton, N.J. & Wijmstra, T.A. (1997). Comparison of terrestrial and marine records of changing climate in the last 500,000 years. *Earth and Planetary Science Letters*, **150**, 171-176.

Ubilla, M. (2004). Mammalian biostratigraphy of Pleistocene fluvial deposits in northern Uruguay, South America. *Proceedings of the Geologists' Association*, 115, in press.

Ubilla, M., Perea, D., Goso, C. & Lorenzo, N. (2003). Late Pleistocene vertebrates from northern Uruguay: tools for biostratigraphic, climatic and environmental reconstruction. *Quaternary International*, **114**, 129-142.

Ueki, T. (2001). The Mitoyo Group along the northern flank of Asan Mountains, central Kagawa Prefecture, southwest Japan; its distribution, stratigraphy, lithofacies and depositional history. *Chigaku Zasshi* (Journal of Geography), **110**, 708-724 (in Japanese).

Ueki, T. & Yamamoto, N. (2003). ^{14}C dating of fossil woods in the terrace gravel beds along the upper reach of the Azusa River, central Japan. *Daiyonki-Kenkyu* (Quaternary Research), **42**, 361-367 (in Japanese).

Ünay, E., Emre, Ö., Erkal, T. & Keçer, M. (2001). The rodent fauna from the Adapazarı pull-apart basin (NW Anatolia): its bearing on the age of the North Anatolian fault. *Geodinamica Acta*, **14**, 169-175.

Van den Berg, M.W. (1994). Neo-tectonics in the Roer Valley Rift System. Style and rate of crustal deformation inferred from syn-tectonic sedimentation. *Geologie en Mijnbouw*, **73**, 143-156.

Van den Berg, M.W. (1996). *Fluvial sequences of the Maas: a 10Ma record of neotectonics and climate change at various time-scales.* Thesis, University of Wageningen. 181pp.

Van den Berg, M.W, & Van Hoof, T. (2001). The Maas terrace sequence at Maastricht, SE Netherlands: evidence for 200 m of late Neogene and Quaternary surface uplift. In: Maddy, D., Macklin, M.G. & Woodward, J.C. (eds.), *River Basin Sediment Systems: Archives of Environmental Change*. Balkema (Abingdon, England): 45-86.

Vandenberghe, J. (1995). Timescales, climate and river development. *Quaternary Science Reviews*, 14, 631-638.

Vandenberghe, J. (2003). Climate forcing of fluvial system development: an evolution of ideas *Quaternary Science Reviews*, **22**, 2053-2060.

Van Vugt, N., Langereis, C. G. & Hilgen, F. J. (2001). Orbital forcing in Pliocene-Pleistocene Mediterranean lacustrine deposits; dominant expression of eccentricity versus precession. Palaeogeography, Palaeoclimatology, Palaeoecology, **172**, 193-205.

Van Vugt, N., Steenbrink, J., Langereis, C. G., Hilgen, F. J. & Meulenkamp, J. E. (1998). Magnetostratigraphy-based astronomical tuning of the early Pliocene lacustrine sediments of Ptolemais (NW Greece) and bed-to-bed correlation with the marine record. *Earth and Planetary Science Letters*, **164**, 535-551.

Veklich, M.F., Matviishina, Z.N. & Ivchenko, A.S. (1993). *Stratigraphical schemes of the Pliocene and Pleistocene sediments of Ukraine* (in Russian), Naukova Dumka, Kiev, 76 pp.

Veldkamp, A. (1992). A 3-D model of Quaternary terrace development, simulations of terrace stratigraphy and valley asymmetry: a case study for the Allier terraces (Limagne, France). *Earth Surface Processes & Landforms*, **17**, 487-500.

Veldkamp, A. & Van den Berg, M.W. (1993). Three-dimensional modelling of Quaternary fluvial dynamics in a climo-tectonic depenent system. A case study of the Maas record (Maastricht, The Netherlands). *Global and Planetary Change*, **8**, 203-218.

Velegrakis, A.F., Dix, J.K. & Collins, M.B. (1999). Late Quaternary evolution of the upper reaches of the Solent River, Southern England, based upon marine geophysical evidence. *Journal of the Geological Society, London*, **156**, 73-87.

Vennemann, T.W. & Hegner, E. (1998). Oxygen, strontium, and neodymium isotope composition of fossil shark teeth as a proxy for the palaeoceanography and palaeoclimatology of the Miocene northern Alpine Paratethys. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **142**, 107-121.

Vidal Romaní, J.R. & Yepes, J. (2001). The Miño river terraces in the sector Chantada-As Neves (Galice-Portugal border). *Acta Geologica Hispanica*, **36**, 149-164.

Vonhof, H.B., Wesselingh, F.P. & Ganssen, G.M. (1998). Reconstruction of the Miocene western Amazonian aquatic system using molluscan isotopic signatures. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **141**, 85-93.

Wayland, E.J. (1934). Rifts, rivers, rains, and early man in Uganda. *Royal Anthropological Institute Journal*, **6**, 64.

West, R.G. (1956). The Quaternary deposits at Hoxne, Suffolk. *Philosophical Transactions of the Royal Society of London*, **B239**, 265-356.

Westaway, R. (2001). Flow in the lower continental crust as a mechanism for the Quaternary uplift of the Rhenish Massif, north-west Europe. In: Maddy, D., Macklin, M.G., Woodward, J.C. (Eds.), *River Basin Sediment Systems: Archives of Environmental Change*. Balkema, Abingdon, England, 87-167.

Westaway, R. (2002a). Geomorphological consequences of weak lower continental crust, and its significance for studies of uplift, landscape evolution, and the interpretation of river terrace sequences. *Geologie en Mijnbouw/Netherlands Journal of Geoscience*, **81**, 283-303.

Westaway, R. (2002b). Long-term river terrace sequences: Evidence for global increases in surface uplift rates in the Late Pliocene and early Middle Pleistocene caused by flow in the lower continental crust induced by surface processes. *Geologie en Mijnbouw/Netherlands Journal of Geoscience*, **81**, 305-328.

Westaway, R. (2002c). The Quaternary evolution of the Gulf of Corinth, central Greece: coupling between surface processes and flow in the lower continental crust. *Tectonophysics*, **348**, 269-318.

Westaway, R. (2003). The effect of changes in the Earth's moment of inertia during glaciation on geomagnetic polarity excursions and reversals: implications for Quaternary chronology. *Current Science*, **84**, 1105-1115.

Westaway, R. (2004). Pliocene and Quaternary surface uplift revealed by sediments of the Loire-Allier river system, France. *Quaternaire*, **15**, 103-115.

Westaway, R. (in press). Late Cenozoic sedimentary sequences in Acre State, southwestern Amazonia: fluvial or tidal? Deductions from the IGCP 449 field trip. *Journal of South American Earth Sciences*, in press.

Westaway, R., & Arger, J. (1996). The Gölbaşı basin, southeastern Turkey: A complex discontinuity in a major strike-slip fault zone. *Journal of the Geological Society of London*, **153**, 729-743.

Westaway, R., & J. Arger (2001). Kinematics of the Malatya-Ovacık fault zone. *Geodinamica Acta*, **14**, 103-131.

Westaway, R., Bridgland, D.R. & Mishra, S. (2003a). Rheological differences between Archean and younger crust determine rates of Quaternary vertical motions revealed by fluvial geomorphology. *Terra Nova*, 15, 287-293.

Westaway, R., Maddy, D. & Bridgland, D. (2002). Flow in the lower continental crust as a mechanism for the Quaternary uplift of south-east England: constraints from the Thames terrace record. *Quaternary Science Reviews*, **21**, 559-603.

Westaway, R., Pringle, M., Yurtmen, S., Demir, T., Bridgland, D.R. & Maddy, D. (2003b). Pliocene and Quaternary surface uplift of western Turkey revealed by long-term river terrace sequences. *Current Science* (New Delhi), **84**, 1090-1101.

Westaway, R., Guillou, H., Yurtmen, S., Demir, T. & Rowbotham, G. (2004b). Constraints on the timing and regional conditions at the start of the present phase of crustal extension in western Turkey, from observations in and around the Denizli region. *Geological Journal*, in press.

Westaway, R., Pringle, M., Yurtmen, S., Demir, T., Bridgland, D.R. & Maddy, D. (2004a). Pliocene and Quaternary regional uplift in western Turkey: The Gediz river terrace staircase and the volcanism at Kula.. *Tectonophysics*, in press.

Wymer, J.J. (1968). *Lower Palaeolithic Archaeology in Britain, as represented by the Thames Valley*. John Baker, London, 429pp.

Wymer, J.J. (1988). Palaeolithic archaeology and the British Quaternary sequence. *Quaternary Science Reviews*, **7**, 79-98.

Wymer, J.J. (1999). *The Lower Palaeolithic occupation on Britain*. Wessex Archaeology and English Heritage, Salisbury, 234 pp + 2nd volume of maps.

Yang Liankang, (2000). The world's highest river terrace, largest number of terraces and thickest loess; the highest Qinghai-Tibet Plateau, the affected area, the form and influence of its uplift 31st International Geological Congress, Rio de Janeiro, Brazil, Abstract Volume (unpaginated)

Yang Liankang (2004). The world's highest river terrace, largest number of terraces, most complete profiles of river evolution and thickest loess: their protection and Geopark construction. *Peoples Daily* 15th June 2004 available online: http://bbs.peopledaily.com.cn/bbs/ReadFile?whichfile=14186&typeid=43 (accessed July 2004).

Yim, W.W. (1994). Offshore Quaternary sediments and their engineering significance in Hong Kong. *Engineering Geology*, **37**, 31-50.

Yurtmen, S., Guillou, H., Westaway, R., Rowbotham, G. & Tatar, O. (2002). Rate of strike-slip motion on the Amanos Fault (Karasu Valley, southern Turkey) constrained by K-Ar dating and geochemical analysis of Quaternary basalts. *Tectonophysics*, **344**, 207-246.

Zagorchev, I. (1995). *Pirin; Geological Guidebook*. Professor Martin Drinov Academic Publishing House, Sofia, 70 pp. ISBN 954-430-379-0.

Zagwijn, W.H. (1985). An outline of the Quaternary stratigraphy of The Netherlands. *Geologie en Mijnbouw*, **64**, 17-24.

Záruba, Q. (1942). Podélný profil Vltavskými terasami mezi Kamýkem a Veltrusy. *Rozpravy České Akademie Věd*, třída II, **52**, 9, 1-39.

Zeman, A. (1982). The main terrace of the Morava River and its relationship to loess sections. *IGCP Project 73/1/24 - Quaternary Glaciations in the Northern Hemisphere*, Rep. No. 7, 253-256.

Zhang, J.F., Zhou, L.P. & Yue, S.Y. (2003). Dating fluvial sediments by optically stimulated luminescenece: selection of equivalent doses for age calculation. *Quaternary Science Reviews,* **22**, 1123-1129.

List of Appendices:

Appendix A – 2002 FLAG/IGCP 449 special issue of *Geologie en Mijnbouw/Netherlands Journal of Geosciences*

Appendix B – 2003 Special Issue of *Current Science* (New Delhi)

Appendix C – 2004 Special Issue of *Quaternaire*

Appendix D – 2004 Special Issue of *Proceedings of the Geologists' Association*

Appendix E – Proposed collection of papers for *Géographie Physique et Quaternaire*

Appendix F – Proposed special issue of *Quaternary science Reviews* (project culmination)

Anticipated IGCP 449 special issue *Quaternary Science Reviews* 2005

Global Correlation of Late Cenozoic fluvial deposits

To be as papers/posters at end-of-project meeting, December 12-18th 2004, Malaga (in many cases final titles and full authorship details unknown):

Regional syntheses:

UK - The British fluvial archive: East Midlands drainage evolution in the context of the British and NW European record - Andy Howard, Peter Allen, Martin Bates, Becky Briant, David Bridgland, Philip Gibbard, Simon Lewis, Darrel Maddy, Jim Rose and Rob Westaway

France - P. Antoine, J-F Pastre, N. Limondin-Louzouet

Germany - R. Becker-Haumann, M. Frechen

Italy - M. Coltorti, P. Pieruccini

Iberia - J.I.S. Navarro & F. Schulte

Eastern Europe - J. Tyracek et al.

Russia (south & north-flowing drainage compared?) - A. Matoshko, V. Drouchits, N. Patyk-Kara

India - Rajiv Sinha, S.K. Tandon et al.

North Africa - A. Ait Hssaine, A. Weisrock, Rafat Zaki

Southern Africa - P. Beaumont, J. McNabb et al.

China – Mo Duanon, Yang Liankang, Liping Zhou

Australasia - G. Nanson (et al.)

South America - E. Latrubesse, J. Stevaux (et al.)

USA - M. Blum (et al.)

Canada – S. Occhietti (St Lawrence) & D. Froese (Yukon)

Middle East & Turkey - T. Demir et al.

Thematic syntheses:

Mammals - D. Schreve et al.

Molluscs – D. Keen et al.

Archaeology - S. Mishra, M.J. White et al.

Innovation in dating: new methods for amino acid analyses – K. Penkman & Matthew Collins

Relation of fluvial sequences to crustal rheology – R. Westaway

Overall synthesis (patterns, correlations) – D.R. Bridgland et al.

FLAG/IGCP 449 special issue of Geologie en Mijnbouw/Netherlands Journal of Geosciences.

Editors: David Bridgland, Durham, and Frank Sirocko, Mainz

Published Volume 81, No.3/4, December 2002

Appendix A

Special IGCP 449 Issue of *Current Science* (New Delhi)

Guest Editor: Dr Rajiv Sinha, University of Kanpur

Published – April 2003 (Vol. 84, No. 8)

List of papers:

1. Guest Editorial – Global correlation of Late Cenozoic fluvial deposits: focus on India (R. Sinha & S.K. Tandon) – 965-966.
2. Facies, fossils and correlation of the late miocene fluvial sequences of the Himalayan foreland basin (S.B. Bhatia) – 1002-1005.
3. Mio-Pliocene sedimentation history the north-western parts of the Himalayan foreland basin, India (Rohtash Kumar, S.K. Ghosh & S. Sangode) – 1006-1013.
4. Magnetostratigraphic Correlation of the Late Cenozoic fluvial sequences from NW Himalaya, India (S.J. Sangode & R. Kumar) – 1014-1024.
5. River systems in the Gangetic plains and their comparison with the Siwaliks: a review (V. Jain & R. Sinha) – 1025-1033.
6. Geomorphology and sedimentology of Piedmont Zone, Ganga Plain, India (U.K. Shukla & D.S. Bora) – 1034-1040.
7. A sediment budget for the Ganga-Brahmaputra catchment (R.J. Wasson) – 1041-1047.
8. Quaternary alluvial stratigraphy and paleoclimatic reconstruction at the Thar margin (M. Jain and S.K. Tandon) – 1048-1055.
9. Late Quaternary fluvial sequences of the southern mainland Kachchh, Western India: Lithostratigraphy and neotectonic implications (D.M. Maurya, S. Bhandari, M.G. Thakkar & L.S. Chamyal) – 1056-1064.
10. Quaternary fluvial sequences of the south Saurashtra, Gujarat, western India (Nilesh Bhatt & U.A. Bhonde) – 1065-1071.
11. Sedimentary records of palaeofloods in the bedrock gorges of the Tapi and Narmada Rivers, central India (Vishwas S. Kale, Sheila Mishra & Victor R. Baker) – 1072-1079.
12. A long Quaternary terrace sequence in the Orontes River valley, Syria: a record of uplift and human occupation (David Bridgland, Graham Philip, Rob Westaway & Mark White) – 1080-1089.
13. Pliocene and Quaternary surface uplift of western Turkey revealed by long-term river terrace sequences (Rob Westaway, Malcolm Pringle, Sema Yurtmen, Tuncer Demir, David Bridgland, George Rowbotham & Darrel Maddy) – 1090-1101.
14. The arsenic cycle in fluvial sediments: mineralogical considerations (B.C. Raymahashay & A.S. Khare) – 1102-1104.
15. The effect of changes in the Earth's moment of inertia during glaciation on geomagnetic polarity excursions and reversals: implications for Quaternary chronology (R.W.C. Westaway) – 1105-1115.

Appendix D

Special Issue of Proceedings of the Geologists' Association

Inaugural meeting of IGCP 449

Global Correlation of Late Cenozoic Fluvial Deposits

Guest editors: D.R. Bridgland, S.K. Tandon & R.W.C. Westaway

To be published as two sets of papers in Vol. 115, in parts 2 & 4

Géographie Physique et Quaternaire
IGCP 449 Special issue

(Arising from December 2002 Annual Meeting in Morocco)

Andre Weisrock & Serge Occhietti – SYNTHESIS PAPER (in French)

Ali Ait Hssaine, Andre Weisrock & Serge Occhietti – QUATERNARY OF MOROCCO (in French)

T. Demir, R.W.C. Westaway, D.R. Bridgland & A. Seyrek – TERRACE STAIRCASES OF THE RIVER EUPHRATES IN SOUTH-EAST TURKEY AND NORTHERN SYRIA.

R.M. Zaki – EARLY AND MIDDLE QUATERNARY SEDIMENTS OF THE NILE IN NORTHERN UPPER EGYPT.

R.W.C.Westaway, A. Matoshko & D.R. Bridgland – EFFECT OF CRUSTAL RHEOLOGY ON UPLIFT RATES IN THE NORTHERN BLACK SEA REGION FROM RIVER TERRACE EVIDENCE.

Martin Stokes, Anne Mather & Astrid Blum – THE APPLICATION OF STREAM-LENGTH GRADIENT INDICES FOR ELUCIDATING ACTIVE TECTONICS IN SE SPAIN

Sheila Mishra – NEOGENE GRAVELS IN PENINSULAR INDIA, THEIR WEATHERING AND RELATION TO HUMAN OCCUPATION.

R.H. Findlay - A TALE OF THREE RIVERS; FLUVIAL IMPACT IN A ZONE OF RAPID UPLIFT, FINISTERRE AND SARAWAGET MOUNTAINS, PAPUA NEW GUINEA.

Special Issue on Tropical Rivers
Geomorphology, Elsevier Science

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