Sedimentology of meandering river deposits: advances and challenges

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INTRODUCTION

Understanding of the form and origin of river meander bends received relevant contributions between the end of the 19th century and the mid-20th century (Thompson, 1876; Tower, 1904; Sellards et al., 1923; Fisk, 1944; Sundborg, 1956; Wright, 1959). In particular, two fundamental contributions provided insights on the morphodynamics of river bends: i) Thompson (1876) provided the first description of the helical secondary flow structure in river bends; and ii) Fisk (1944) highlighted the temporal evolution of the lower Mississippi River, mapping its bends as mutable elements in unprecedented detail. Subsequent research efforts sought to link the helical flow pattern with the lateral mobility of meanders and culminated in the facies models by Allen (1963) and Bernard & Major (1963). These models associated the lateral shift of river bends with the development of clinostratified, fining-upward point-bar deposits. These theories were promptly supported by studies of modern rivers (e.g. Bluck, 1971; Jackson, 1975, 1976a, b; Nanson, 1980, 1981), validated with observations from the rock record (e.g. Allen, 1965; Puigdefabregas & Vliet, 1978) and were also strengthened by the first direct measurements of flow velocities in river bends (Bathurst et al., 1977). In parallel, new morphometric studies linked metrics of meandering channels (e.g. width, depth) and hydraulic parameters (Schumm, 1972; Ethridge & Schumm, 1978), providing the basis for development of palaeohydraulic reconstructions (Hajek & Heller, 2012; Hampson et al., 2013). The first ICFS (International Congress of Fluvial Sedimentology) meeting – held in 1977 in Calgary, Canada – contributed to disseminating, applying and refining these models.

During the 1980s, facies models were further improved, notably with the recognition and classification of ‘Inclined Heterolithic Stratification’ (Thomas et al., 1987) and reinforced through increasingly detailed comparisons between modern and ancient systems (e.g. Nanson, 1980; Dietrich & Smith, 1983; Smith, 1988; Willis, 1989). Since the early 1990s, the implementation of new technologies, including ground penetrating radar, acoustic Doppler current profilers, 3D outcrop imaging (e.g. using LiDAR and photogrammetry), 3D reflection seismic, together with enhanced approaches to numerical and laboratory experimental modeling, promoted development of new approaches for understanding meandering rivers. These developments now make it increasingly possible to consider the subject from complementary points of view (Kleinhans et al., 2010) and to investigate more complex dynamic flow-form interactions over larger spatial and temporal scales. Thus, recent developments help improve our understanding and enable us to challenge long-held beliefs about meandering rivers.

This IAS Special Publication has arisen in part from contributions to a Special Session titled ‘Fluvial meanders and their sedimentary products in the fossil record’, which was held during the 32nd IAS International Meeting (May 2016, Marrakech, Morocco). This introductory paper outlines the key advances made in the study of meandering rivers and their deposits, and frames the scientific contributions of this volume within specific research themes. The resulting holistic view on meandering rivers provides insight to outstanding issues, which we hope will become the focus of follow-on studies that will seek to advance the state-of-the-science yet further.

The articles that form this volume demonstrate the breadth of scope in the research that is currently being undertaken in fluvial sedimentology. The organisation of the volume seeks to reflect
how the research contributions variably focus on geological controls, processes and products (Fig. 1). Collectively these articles demonstrate how several connected strands of research contribute to a more integrated understanding of the sedimentology of meandering rivers, which is leading to the advancement of both fundamental and applied science. Within this field of research, four themes have been identified as being particularly topical; these are discussed below.

**ESTABLISHED MODELS AND FORTHCOMING WORKS**

Four fundamental research themes that capture the breadth of contributions to this volume (Fig. 2) have fascinated fluvial sedimentologists and geomorphologists working on meandering rivers since the early 1970s: i) channel-bend growth and related point-bar facies distribution; ii) mechanisms of meander-bend cutoff; iii) meandering river channels and vegetation cover; and iv) geometries of meander-belt sedimentary bodies. For each of these themes, the main research advances and contributions in this volume are summarised herein.

**Channel-bend growth and related point-bar facies distribution**

*Previous studies*

The advent of GPR investigations of the shallow subsurface sedimentary record marked a revolutionary step in linking the planform evolution of braided rivers with stratatal patterns in their deposits (e.g. Bristow & Best, 1993; Lunt & Bridge, 2004; Lunt et al., 2004). Ground Penetrating Radar was also used to investigate meandering river deposits (Bridge et al., 1995). However, the loss of the electromagnetic signal in bar-top mud deposits limits its application principally to relatively sand-prone point bars (Kostic & Aigner, 2007), and methods such as parametric echo-sounders may need to be deployed as an alternative (e.g. Sambrook Smith et al., 2016). The majority of modern point-bar sedimentary facies – including mud-prone deposits – were investigated through vibracoring, following the pioneering work of Smith (1988), who identified commonalities between sedimentary features of some modern tidally influenced rivers and those of the Cretaceous McMurray Formation, which forms the Athabasca oil sands (Alberta, Canada). Development of the Athabasca oil sands – host of the largest heavy crude oil deposit in the world – strongly encouraged improved understanding of fluvial point-bar deposits, especially with regards to how sedimentary facies and architecture result from specific channel planform transformations.

Burge & Smith (1999) provided the first significant change to classical facies models by highlighting the common occurrence of translating meander bends (Daniel, 1971; Jackson, 1976a) and associated eddy-accretion deposits. This model was further refined by Smith et al. (2009, 2011), who investigated counter-point-bar and eddy-accretion deposits, and linked their development with specific conditions of outer bank erodibility. Despite their common occurrence in modern settings, translating (or ‘downstream migrating’, sensu Ghinassi et al., 2016) point bars and related counter-point-bar and eddy-accretion deposits remain relatively poorly documented in the rock record (Ghinassi & Ielpi, 2015), except in rare cases for which high-resolution seismic data or planform exposures are available (Hubbard et al., 2011; Ielpi & Ghinassi, 2014; Alqahtani et al., 2015; Wu et al., 2015). The noteworthy control of meander-bend planform transformations on spatial distribution of point-bar sedimentary facies has been recently highlighted through numerical simulations by Yan et al. (2017).

In the frame of understanding different styles of point-bar facies distribution, a special focus is often placed on deposits accumulated at the fluvial–marine transition zone, especially with the aim of unravelling the interaction between fluvial and tidal processes. Pioneering studies of Jones et al. (1993) and van den Berg et al. (2007) linked variations in fluvial discharge with sand-mud alternations in Inclined Heterolithic Stratification. Recent studies on the fluvial-tidal transition zone (see Ashworth et al., 2015 for a review) have focussed their attention on the role of tidal currents in modulating fluvial point-bar sedimentation (Dalrymple & Choi, 2007; Martinius & Gowland, 2011; Shiers et al., 2014; Carling et al., 2015; Gugliotta et al., 2016a, b) and have highlighted the different aspects of tidal signature on point-bar sedimentation. Choi et al. (2004) highlighted the spatial distribution of rhythmic tidal signatures in modern inclined heterolithic deposits. Jablonski & Dalrymple (2016) detected seasonality and climatic cyclicity
Fig. 1. Diagram that summarises the topics covered by each article in the volume. The flow chart on the left-hand side illustrates linkages between higher-order controls, processes, products and use of all related insight in applied contexts. For each article, as labelled, vertical black bars indicate which of these areas are covered and the position of stars indicates the primary focus of each. The four particular research themes discussed in more detail in the text are denoted by the coloured stars, as explained in legend. Allogenic controls (tectonics, eustatic sea-level changes, climate) are known to exert influence on fluvial systems over a range of timescales (e.g. through changes in sediment supply rate and calibre and in gradient). These factors are argued to affect fluvial systems through influences on both the behaviour of river systems and their long-term preservation in the stratigraphic record. Autogenic processes and river morphodynamics are distinguished, for convenience, because although certain processes will reflect the morphodynamic self-organisation of the river reach under study (e.g. neck cutoff), other processes might act independently (e.g. distant avulsions, shoreline progradation). Whereas studies of ancient successions allow consideration of what is ultimately preserved, studies of modern rivers permit observation of hydrodynamic processes and direct linkages of these to geomorphological and facies characteristics. It is therefore evident that integration is needed to obtain a more comprehensive understanding of the geological record of meandering rivers and to achieve improved predictions of subsurface fluvial successions. The order of articles in this volume largely follows the flow-chart in the figure and is indicated by the order in which the bars are laid out, from left to right.
in tidally influenced point-bar deposits of the Cretaceous McMurray Formation. A spectrum of tidal influences spanning from the daily modulation of fluvial currents to the effects of tidal bores has been described by Martinius & Gowland (2011). The sedimentology of fluid muds in tide-dominated systems was investigated by Mackay & Dalrymple (2011). Olariu et al. (2015) highlighted the role of mutually evasive currents in modulating sedimentation in tidally influenced fluvial point bars.

**Contributions to this volume**

In this volume, contributions relating to point-bar sedimentary dynamics are provided by Blanckaert, Reesink, Russell et al., Simon et al., Johnston & Holbrook and Swan et al. Additionally, Shiers et al. and Durkin et al. focus on point-bar deposits accumulated in the distal part of alluvial plains, under the effects of processes that are characteristic of the fluvial-tidal transition zone.

Blanckaert reviews recent research on hydro-sedimentological processes and on their interaction...
in modern meandering rivers, highlighting and discussing the dominant controls on flow distribution. Reesink focuses on the bed-form scale and undertakes analyses of the preserved architecture of unit-bar cross strata in outcrops, highlighting how systematic measurements of these deposits may reveal valuable details of the formative fluvial palaeoenvironment. In seeking to address the discrepancy between the wide range of meander-bend planforms and the limited facies variability incorporated in facies models, Russell et al. present a new method to predict variable distribution of heterogeneities in point-bars, based on integration of meander-shape and meander scroll-bar pattern; the method is tested on Cretaceous deposits of the McMurray Formation (Alberta, Canada) and on Eocene deposits of the Montanyana Group (Spain). Mud-prone point-bar deposits are the focus of Simon et al. and Johnston & Holbrook. Simon et al. describe an exhumed point-bar element of the Permian upper Clear Fork Formation (Texas), highlighting the role of oblique accretion processes associated with suspended sediments plastering onto the steep inner channel bank. Johnston & Holbrook show mud-prone and sand-prone accretionary sets in a point-bar element of the Cretaceous Dinosaur Park Formation (Alberta, Canada) and link their formation with different styles of meander-bend transformations. Swan et al. illustrate the use of planform exposures of the Upper Jurassic Morrison Formation to reconstruct morphodynamic evolution of sandy fluvial point bars and to determine their internal facies distribution, highlighting how some sand-rich fluvial systems may previously have been interpreted incorrectly as deposits of braided rivers due to reliance on existing facies models of limited predictive capability. Focusing on the Campanian Neslen Formation (Utah, USA), Shiers et al. describe point-bar facies assemblages that only partially conform to those depicted in classical facies models and document and interpret substantial variability in point-bar architecture and internal facies distribution. Resultant models demonstrate how a range of interactions between allogenic (e.g. accommodation generation, fluvial discharge variations) and autogenic (e.g. backwater processes, presence of peat mires) processes can give rise to point-bar and related architectural elements with a variety of forms. Durkin et al. investigate transitions from point bars to counter-point bars along six modern river bends with varying channel scale, discharge and tidal influence. Results demonstrate downstream changes in net-to-gross ratio and provide criteria to detect counter-point bar deposits where a concave scroll pattern is not necessarily evident in planform.

Further developments

Although significant progress has been made in recent years in linking river-bend morphodynamics with related sedimentary products, there remains a need to improve our knowledge about how different hydrodynamic configurations are recorded in the facies architecture of point-bar deposits. Of particular importance is the role of partial preservation: most meander-belt deposits are lost to erosion and only a small portion of these deposits is ultimately preserved (Paola & Borgman, 1991; van de Lageweg et al., 2013; Reesink et al., 2015; Durkin et al., 2017). The potential for deposition is linked to the sediment flux, which increases exponentially with discharge. Due to this exponential relationship, it is commonly assumed that sediment deposited by floods constitutes the majority of river-channel deposits. However, erosion and deposition are fundamentally controlled by the conservation of mass: along-stream changes in the transfer of sediment and not the absolute quantity of sediment transport, dictates the pattern of deposition. Consequently, erosion, deposition and sedimentary preservation must be affected greatly by increases in local gradients in water-surface slope and sediment transport, such as created by chute and neck cutoffs.

Furthermore, it is now known that the water-flow structure varies within the same meander bend at different flood stages (Kasvi et al. 2013; 2017), that overbank flood flows significantly modify the flow structure within bends (Loveless et al. 2000; Wormleaton et al. 2004) and that overbank deposition is a key control on the development of meanders (Van Dijk et al., 2013a, b). Although the importance of these processes is widely acknowledged, the ways in which they are recorded in point-bar deposits and their ultimate preservation potential still needs to be further elucidated.

Although past research has offered notable insights into the detection of tidal influence in fluvial point-bar sedimentation at the bedform scale, less attention has hitherto been paid to understanding the role of tidal currents in shaping bar stratal architecture or controlling vertical and streamwise variations in sediment grain-size.
Assessment of these influences will require additional studies of modern meander bends, complemented with observations from tidal channels. Additionally, recognition of the location of channel deposits along the fluvial–marine transition zone (e.g. in terms of distance from a contemporaneous shoreline) is commonly attempted based on analysis of trace-fossil assemblages (e.g. Gingras et al., 2012). A predictive tool that integrates knowledge of the spatial distribution of physical sedimentary structures is still lacking (Dalrymple et al., 2015). Facies models developed for tidally influenced fluvial point bars should also be compared with those pertaining to muddy point bars formed far inland from tidal influence (Taylor & Woodyer, 1978; Jackson, 1981; Brooks, 2003). This comparison will contribute to the identification of distinctive features with which to detect tidally influenced fluvial point-bar deposits in the fossil record. In this context, the interference between backwater hydrodynamics and tidal–fluvial interaction was investigated in modern settings (Blum et al., 2013) and efforts to detect their effects in terms of down-dip changes of architecture of distributary channel bodies were carried out by Colombera et al. (2016) and Fernandes et al. (2016). These studies provide a good starting point for further research into the diverse dynamics that characterise deposition in the zone of fluvial–marine transition.

Mechanisms of meander-bend cutoff

Previous studies

The process of abandonment of a channel reach, with the concomitant activation of a new river course (e.g. avulsion processes), has been widely documented in fluvial systems (Smith et al., 1989; Slingerland & Smith, 1998, 2004; Morozova & Smith, 2000; Aslan et al., 2005). In meandering rivers this process can occur at the bend scale and is known as meander-bend cutoff (Brice, 1974; Lewis & Lewin, 1983; Gagliano & Howard, 1984; Erskine et al., 1992; Constantine & Dunne, 2008; Toonen et al., 2012). The best-known of such processes is neck cutoff, whereby growing meanders intersect each other to cut off a meander loop (Lewis & Lewin, 1983). Less attention has been paid to chute cutoff, which occurs when a channel (i.e. chute channel) incises the inner side of the point bar (McGowen & Garner, 1970; Hooke, 2013). Chute channels can break through the upstream edge of a meander neck during major floods (Johnson & Paynter, 1967) but they can also form on the downstream side of the bar and step progressively upstream (Gay et al., 1998). The latter mechanism recently received attention through laboratory experiments (van Dijk et al., 2012) and outcrop studies (Ghinassi, 2011). Constantine et al. (2010) showed that these two processes can occur together. Zinger et al. (2011) highlighted the importance of cutoff processes in river dynamics, demonstrating that extreme sediment pulses are released to the main channel after occurrence of a cutoff. Such local dynamics of enhanced erosion and deposition have great potential to be preserved in the sedimentary record. Indeed, channel-fill deposits generated by cutoff events are important elements within channel-belt bodies; they give rise to significant lithological heterogeneities, which can control both the lateral channel mobility of active channels (Smith et al., 2010; Güneralp et al., 2011; Bogoni et al., 2017) and fluid flow through channel-belt deposits (Colombera et al., 2017, and references therein). In this context, different types of oxbow-lake infills (Toonen et al., 2012) have been demonstrated to exert a notable control on connectivity between point-bar bodies (Donselaar & Overeem, 2008). This has important implications for reservoir development and groundwater management.

Contributions to this volume

In this volume, articles that discuss mechanisms of meander-bend cutoff are provided by Richards et al., Viero et al., Schwendel et al. and Fustic et al. Richards et al. present a dataset of measurements of the three-dimensional flow through neck cutoffs with complex configurations that includes valuable observations on helical flows, recirculation and zones with stagnated flow. Viero et al. present a numerical modelling approach applied to two case studies (Sacramento River, California; Cecina River, Italy) and highlight the role of channelised flow inertia and of topographic and sedimentary floodplain heterogeneities in promoting channelised flow. Schwendel et al. investigate the infill of abandoned chute channels and of channel segments that were abandoned after neck cutoff, from meanders of the Rio Beni (Bolivian Amazon basin). Results demonstrate how patterns of infill vary in relation to hydrological connectivity and distance to the main active channel. Fustic et al. describe channelised deposits encased within a large-scale
point-bar element exposed in the McMurray Formation type section (Athabasca River, Alberta, Canada). These deposits are interpreted as relics of the infill of larger channel incisions that represent unsuccessful channel cutoffs or avulsions.

Further developments

Although significant advances have been made in understanding cutoff processes, a detailed model that attempts to link different mechanisms of cutoff with the style of infill of cutoff channels is yet to be developed. This is of particular importance because chute cutoff processes enable the transition from meandering to braiding (Kleinhans & Van den Berg, 2011). The lack of more sophisticated interpretative models is one of the reasons why interpretations of the rock record commonly take on a binary meandering-versus-braiding view, rather than allowing for transitional systems with individual flow-form characteristics.

Furthermore, the increased water-surface gradients created by cutoff process promote periods of accelerated planform change, increases in local sediment transport gradients and generate bed-scale pulses of sediment with effects that propagate both downstream and upstream, then eventually dissipate (Zinger et al., 2011). Similarly, the consequence of shifting patterns of bed shear and sediment transport at confluences during large changes in the relative discharge of the upstream branches ought to lead to significant pulses of sediment redistribution within rivers. It is reasonable to assume that such local dynamics are recorded and preserved in the rock record; yet no diagnostic criteria exist for the distinction of such local allogenic controls from the migration of meanders through autogenic bank-pull and bar-push mechanisms (Parker et al., 2011; van de Lageweg et al., 2014). Consequently, it also remains unclear as to whether there is preferential preservation of specific morphological elements, or events, and therefore to what extent the deposits of a river provide biased information on the formative geomorphology.

Meandering river channels and vegetation cover

Previous studies

The relationship between the presence of vegetation cover and the development of meandering river channels has been the focus of considerable study by fluvial sedimentologists in recent years. Davies & Gibling (2010) noted a parallel between appearance of riparian vegetation and an increase of occurrence of deposits indicative of sinuous rivers in the rock record. Such a notion was in agreement with observations from a number of field-based studies (Ielpi et al., 2015) and laboratory experiments (van Dijk et al., 2013b), which indicated that the presence of vegetation favours the development of sinuous channels (Tal & Paola, 2007, 2010) by acting to stabilise river banks both through rooting and by encouraging retention of pedogenic cohesive mud. These notions supported the idea that pre-vegetation channels were dominantly shallow and braided in planform. This form, designated the ‘sheet-braided’ river style by Cotter (1978), has been considered representative of Precambrian fluvial styles.

However, other geological evidence supports the presence of plan forms indicative of meandering in some non-vegetated settings; such evidence includes the documentation of laterally accreting channels in pre-Devonian deposits (Long, 2011; Ielpi & Rainbird, 2016; Santos & Owen, 2016) and the presence of sinuous fluvial channels draining arid, non-vegetated areas (Matsubara et al., 2015). Laboratory experiments by Smith (1998), Peakall et al. (2007) and van de Lageweg et al. (2014) also showed that sinuous channels were able to be produced and maintained on a non-vegetated substratum. The occurrence of meandering channels on extra-terrestrial surfaces (Lorenz et al., 2008) further challenges the notion of a paucity of meandering channels in non-vegetated settings.

Contributions to this volume

In the present volume, integrating a review of pre-existing literature with field evidence, the papers by McMahon & Davies and Ielpi et al. summarise the two main views on interaction between vegetation growth and development of meandering river channels. McMahon & Davies, supporting their claims with field data from the 1 Ga Torridon Group (Scotland), argue that meandering planforms were less frequent on pre-vegetation Earth and that there is a tangible shift in the physical nature of global alluvium, coincident with the evolution of land plants. Ielpi et al. show laterally accreting deposits from five sedimentary rock units deposited on Laurentia between 1.6 to 0.7 Ga. Undertaking detailed sedimentary, architectural and palaeoflow analyses, they recognise the presence of lateral-accretion sets, a feature that was previously thought to be rare or absent in these deposits.
Further developments

The uncertainty in interpretations arising from complexity in the relationships between products and processes ensure that the relative roles of factors controlling the evolution of sinuous channels, including vegetation, remain of considerable research interest (Davies, 2017; Santos et al., 2017a,b). Further architectural studies are needed to assess morphodynamic feedbacks and adequately explain the dynamics and preservation of point-bar deposits in pre-vegetation and extra-terrestrial river systems. A combination of deduction based on laboratory and numerical experiments, induction based on field-based studies of modern rivers in different environments and abduction based on analysis of preserved deposits present in the geological record (cf. Kleinhans, 2010) is needed in order to generate a balanced understanding of the development of meandering channels that is applicable to the full range of boundary conditions within which meanders are found.

Geometries of meander-belt sedimentary bodies

Previous studies

Channel-belt deposits generated by the lateral shift and avulsion of sinuous channels represent sedimentary bodies of primary interest as hydrocarbon reservoirs and aquifers (Hajek et al., 2010). The width-to-thickness aspect ratios of these sedimentary bodies have been compared with those of braid belts by Gibling (2006) and Colombera et al. (2013), who provide criteria to distinguish between these sedimentary bodies. Recently, the internal architecture of channel-belt bodies has received significant attention and has been the focus of several studies mainly based on numerical simulations and laboratory experiments. Using numerical simulations, Willis & Tang (2011) showed that different styles of point-bar planform transformations exert a remarkable control in shaping the basal surface of channel-belt bodies and distributing facies heterogeneities. These studies also highlight how a combination of different styles of planform behaviour with a variable aggradation rate strongly controls intra-channel-belt connectivity. Laboratory experiments by van de Lageweg et al. (2013) established a relationship between preserved set thickness and morphology formed by a meandering channel. Numerical simulation by van de Lageweg et al. (2016) quantified the effects of bed aggradation on the preservation of meandering channel morphologies and provided support to qualitative studies from the rock record (Ghinassi et al., 2014).

Contributions to this volume

Geometries of meander-belt sedimentary bodies are analysed here by Willis & Sech (a, b), Yan et al., Hartley et al. and Viseras et al. The two contributions by Willis & Sech are based on numerical simulations. Willis & Sech (a) predict the geometry and facies of channel belts by considering patterns of erosion and deposition during channel migration and underscore that facies models for channel belts need to better account for changes in the shape and position of channels, rather than present static views of river pattern. Willis & Sech (b) predict variations in fluid-flow patterns through subsurface hydrocarbon reservoirs and aquifers with improved consideration of 3D facies heterogeneity in channel-belt deposits. Yan et al. apply a 3D forward stratigraphic model, which is able to generate realistic architectural geometries and incorporate different types of facies heterogeneity, to a quantitative analysis of the static connectivity of point-bar sands based on data from geological analogues. Hartley et al. document amalgamated sandy meander belts from modern basins and the stratigraphic record, remarking that their recognition in the rock record is hindered by overlaps in facies characteristics between channel deposits of sandy meandering rivers and braided rivers. Viseras et al. present an outcrop/behind-outcrop multidisciplinary study of Triassic red beds from central Spain and make recommendations on how to identify and characterise poorly exposed ancient meander belts.

Further developments

Gaining improved understanding of intra-channel-belt facies heterogeneity has important applied implications, notably the characterisation of styles of compartmentalisation of sands by fine-grained deposits of different types (e.g. Colombera et al., 2017; Yan et al., 2017) and prediction of petrophysical heterogeneity (e.g. Burton & Wood, 2013; Nordahl et al., 2014). At present, numerical modelling and laboratory experiments are the most powerful tools for understanding mechanisms controlling the internal architecture of channel-belt deposits formed by meandering channels,
but improved remote sensing capabilities and the continuing efforts in capturing the variability in architectural styles from outcrop and modern analogues are also important sources of primary data. It is important that results from future research are translated to predictive tools that can be readily applied in subsurface studies.

A note on anthropogenic influences

Our future understanding of meandering rivers is contingent upon a multidisciplinary approach, which should be aimed at developing a new generation of quantitative fluvial facies models founded on datasets populated with information obtained from a broad range of investigations of modern and ancient rivers, laboratory experiments and numerical simulations. Although a comparison between these different datasets would be a fundamental step in advancing understanding in the discipline of fluvial sedimentology, it should be carried out considering the significance of anthropogenic effects on present-day fluvial systems. Nowadays, most rivers – whether they be considered to possess braided or meandering plan forms (or perhaps more usually combinations thereof) – are not hosted in pristine natural environments. The majority of present-day rivers are actively evolving under the influence of marked anthropogenic controls. Such controls have induced river behaviour and associated patterns of sediment erosion, transport and deposition that are difficult to predict. Therefore, understanding the continued evolution of meandering rivers in the Anthropocene represents an active and important field of research (e.g. Brooks et al., 2003; Morais et al., 2016; Munoz et al., 2018). The effects of human-related activities (e.g. deforestation, loss of riparian vegetation, conversion of multi-channel systems to single-channel systems, channelisation [dredging] and bank revetments, flow regulation and damming, agricultural development, dispersion of pollutants, spreading of allochthonous aquatic faunas) need to be recognised in order to develop a new set of sedimentological models to assist with the management of rapidly evolving fluvial landscapes. Such models will enable valuable comparison of present-day fluvial deposits with the stratigraphic record and may, in turn, serve to predict the future effects of anthropogenic factors on river behaviour and patterns of erosion and sedimentation.

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