

A celebration of the twentieth anniversary of the Fluvial Archives Group (FLAG)

Rebecca M. Briant^{a,*}, David R. Bridgland^b, Stephane Cordier^c, Gilles Rixhon^{d,e}, Ronald van Balen^f

^aDepartment of Geography, Birkbeck, University of London, Malet Street, London, WC1E 7HX, United Kingdom

^bDepartment of Geography, Upper Mountjoy, Durham, DH1 3LE, United Kingdom

^cDépartement de Géographie-UMR (Unité Mixte de Recherche) 8591 CNRS (Centre national de la recherche scientifique)-Université Paris 1-Université Paris Est Créteil, 61 avenue du Général de Gaulle, 94010, Créteil Cedex, France

^dEcole Nationale du Génie de l'Eau et de l'Environnement de Strasbourg (ENGEES), 1 Quai Koch, 67070 Strasbourg, France

^eLaboratoire Image Ville Environnement (LIVE)-UMR (Unité Mixte de Recherche) 7362 CNRS (Centre national de la recherche scientifique)-University of Strasbourg, 3 rue de l'Argonne, 67000 Strasbourg, France

^fDepartment of Earth Sciences, Vrije Universiteit Amsterdam, De Boelelaan 1085, 1081 HV, Amsterdam, The Netherlands

*Corresponding author e-mail address: b.briant@bbk.ac.uk

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FLAG AT 20: NEW RESEARCH THEMES AND FOCI

The Fluvial Archives Group (FLAG) was founded in 1996 to bring together researchers looking at the development of fluvial systems over multiple timescales and global spatial scales. Fluvial archives of various types are important not just because they provide insights into past landscape dynamics, e.g., driven by climate or crustal processes, but also because they frequently contain fossil or archaeological material for which they provide stratigraphic control. Since 1996, FLAG has evolved from a research group of the British Quaternary Research Association into an organisation with around 500 members in over 20 countries. The research group held 12 biennial meetings, comprising both presentations and field excursions, as well as multiple themed sessions at international conferences. These had resulted by 2017 in 19 journal special issues, all fully detailed by Cordier et al. (2017). The goals of FLAG are: provision of a community for discussion of key issues concerning fluvial archives, including organising the aforementioned biennial discussion/field meetings, sessions at relevant international conferences, and special issues of journals; continued promotion of the value of fluvial archives by means of readily accessible published information; and coordination of activity with other research groupings with overlapping interests, e.g., by co-convening sessions and collaborating on publications.

Themes/foci

Over time, the exact focus of FLAG activities has evolved, reflecting changes in approach, often relating to the

availability of different techniques for studying fluvial archives, such as improved dating techniques (e.g., Rixhon et al., 2017) and landscape evolution modelling (e.g., Veldkamp et al., 2017). In 2015, following discussion amongst the executive and after presentation at a business meeting at the 2015 International Union for Quaternary Research (INQUA) Congress in Nagoya, Japan, FLAG activities were reorganized into eight foci, grouped within three key themes:

- (1) Natural and anthropogenic forcing at various timescales:
 - (1.1) Fluvial response to long-term (Pleistocene) climate and sea-level change, tectonic activity, and other crustal movements;
 - (1.2) Fluvial response to Holocene climate, sea-level change, and anthropogenic forcing.
- (2) Approaches and methods for studying fluvial archives:
 - (2.1) Study of palaeoenvironmental, biostratigraphical, and archaeological data contained within fluvial archives (fluvial deposits and landforms, alluvial fans, lakes, and caves), including geoarchaeology of river corridors;
 - (2.2) Modelling and otherwise quantifying long-term evolution of fluvial systems;
 - (2.3) Geochronological constraints on fluvial archives; and
 - (2.4) Application of new field techniques to fluvial archives, e.g. geophysics.
- (3) Fluvial activity in relation to present and future climate and environmental change:
 - (3.1) Applied elements of fluvial archives, e.g., economic geology (aggregates and placer deposits)

or archives as sources of baseline information for river restoration; and

- (3.2) Using fluvial archives to inform future climate change planning.

From September 12 to 18, 2016, the twentieth anniversary meeting of FLAG was held in Kielce-Suchedniów, Poland (Fig. 1), followed by field visits to the area of Oder-Warthe glaciation and the foothills of the Carpathians, covering a wide range of fluvial archives and timescales (video montage available at: <http://flag2016suchedniow.pev.pl/>). This thematic set of papers presented in this volume of *Quaternary Research* comprises a selection showcasing research that was presented at this meeting. Below, we show how each of the 10 papers presented contributes to one or more of the themes identified above.

CONTENTS OF THE THEMATIC SET

Foci 1.1 and 1.2 are overwhelmingly represented, with all papers relating to fluvial responses to external forcing factors over different timescales, in addition to contributing to other foci. In relation to the oldest timescales of focus 1.1, these studies often lack direct geochronological control and fluvial responses need to be investigated using alternative approaches. For example, Anton and Muñoz Martín (this thematic set) apply new techniques (focus 2.2) to quantify the amount of material removed from the Duero basin in Spain since capture-based opening. They test multiple methodologies and provide evidence for which methodology was most effective in reconstructing the pre-capture surface, to guide future research. In addition, the authors use the comparison of reconstructed denudation rates with other systems to suggest an age of <3 Ma for basin opening, an event that is otherwise chronologically unconstrained. Similarly, Soria-Jauregui et al. (2018, this thematic set) use geomorphic indices (focus 2.2) to study the impact of the endo- to exorheic transition of the Ebro basin in Spain on the subsequent Ebro river system. There is still some debate about the age of the transition, either before or after the Messinian. Soria-Jaureguia et al. (2018, this thematic set) show that the Ebro and the Pyrenean tributaries are at a mature stage of development, which seems to agree with a Tortonian or Messinian age of the transition. The tributaries in the south are still in a transient state. Finally, Krzyszkowski et al. (2018, this thematic set) outline the drainage evolution of the Polish Sudeten Foreland since the Saalian glaciation. A provenance-based (gravels and heavy minerals) reconstruction of the buried, pre-glacial, Pliocene–Early Pleistocene fluvial system shows that there was a significantly different drainage pattern in the Pliocene to early Middle Pleistocene, with the Palaeo–Nysa Kłodzka operating as the main river in an area now dominated by the Odra (Oder). Also noted as important, in this part of Poland and more widely, are variations in crustal properties and the extent of mafic underplating of the crust, both seeming to have affected

the distribution and preservation patterns of Quaternary fluvial deposits.

Studies of fluvial evolution in the recent time periods, whilst still contributing to focus 1.1, have better age control, often using optically stimulated luminescence (OSL) dating (focus 2.3). Thus, Olszak et al. (2018, this thematic set) present a comprehensive range of new OSL ages ranging from 3 to ~140 ka from the Dunajec River catchment in the northern foreland of the Tatra Mountains of Poland. The Tatra Mountains were repeatedly glaciated during the Quaternary and fluvial aggradations of various types (alluvial fans and cut-and-fill terraces) have traditionally been linked to periods of cold climate. Olszak et al. (2018, this thematic set) show that, instead, fluvial aggradation in this region since ~140 ka has overwhelmingly occurred during periods of warmer climate. They argue that sediment produced by glaciers during cold climate phases was stored and then extensively reworked during warmer phases, suggesting a new model of fluvial response to climate in glaciated regions. In a contrasting Mediterranean region, Avsin et al. (2019, this volume) also present new OSL ages from a low terrace of the Göksu River in the Mut Basin, Turkey. These ages of ~240 to 170 ka place deposition of this terrace into Marine Oxygen Isotope Stages 7 and 6. These two groups of ages correspond to two different lithofacies identified in the field. The authors argue that the presence of similar lithofacies transitions in higher terrace deposits suggest a similar response to climate recorded in all the deposits. This research suggests a much lower uplift rate than has been published in previous studies. Despite being in the Mediterranean, Avsin et al. (2019, this thematic set) record similarities with temperate-periglacial river systems in Europe and attribute any outstanding differences to different vegetation cover and greater thaw of more intense snowfalls.

At still shorter timescales, four papers explore fluvial evolution over the late glacial and Holocene (both foci 1.1 and 1.2). This research all has strong geochronological control and explores the interaction of fluvial systems not just with climate or tectonics but with other geomorphic systems and human activity, as shown in the geoarchaeological data available from some sequences. For example, Woolderink et al. (2018, this thematic set) take a different approach to the well-studied terrace sequences of the Lower Meuse in the late glacial and Holocene, by looking for reach-scale differences across different tectonic regions. The work integrates a database of previous sites with new, radiocarbon-dated field data (focus 2.3) in regions of specific interest using GIS mapping (focus 2.4). This has enabled the authors to build a more nuanced reconstruction of changes in river planform, not just in relation to climate change, but also depending on tectonic movement, subsurface composition, and upstream-downstream propagation of morphological change. Late-glacial terrace fragments are best preserved in downstream reaches of the study area, where there is relative uplift, e.g., in the Peel and Venlo Blocks. In contrast, Holocene terraces are best developed upstream, in the Roer Valley Graben, but



Figure 1. (color online) Fluvial Archives Group (FLAG) 2016 participants outside the conference venue in Kielce-Suchedniów, Poland.

also the Campine Block. Interactions between landscape elements are also seen in China in the work of Wang et al. (2018, this thematic set), who report on the interaction between fluvial and aeolian processes and the response of both to climate change during the late glacial and Holocene in the semiarid area of northwest China, a region visited during a FLAG meeting during 2017 (Hu et al., 2017). The data come from sedimentary sequences that have been dated by OSL methods, consisting of gravels and sand that were deposited during cold periods and finer-grained sediments (flood loams) representing warmer episodes. During cold-to-warm climatic transitions, the river incised and channel and floodplain sediments were subject to deflation, leading to the formation of dunes, which were subsequently buried by flood loam deposition early in the following warm period. Wang et al. (2018, this thematic set) suggest that fluctuations of the Southeast Asian monsoon as an agent for transporting moisture have perhaps driven the interactions between fluvial and aeolian processes in this dryland environment.

Geoarchaeological connections are seen clearly in two papers by Kalicki et al. (2018, this thematic set) and Niebieszczański et al. (2018, this thematic set). Kalicki et al. (2018, this thematic set) summarise the body of continuing research at the University of Kielce, upon which the field component of the FLAG 2016 meeting was based. This is a dominantly geoarchaeologically inspired research

programme, contextualized within the Late Quaternary fluvial evolution (based on river terraces and sedimentary evidence) of the Holy Cross Mountain region. The work points to increasing anthropogenic influence on landscape development since the Middle Ages, as revealed by research in the valleys of the Kamionka, Kamienna, Czarna Konecka, and Nida rivers, particularly in relation to the construction of numerous artificial ponds, channels, and water-power installations, resulting in significant changes in river patterns and regimes and problems for present and future management. Niebieszczański et al. (2018, this thematic set) show how multiple phases of Neolithic and Bronze Age tell occupation in Greece are strongly related to their surrounding floodplain environment. The researchers use geophysical techniques (focus 2.4) along with more established palaeoenvironmental and radiocarbon dating methods to determine the nature of the relationships between archaeological and fluvial sedimentation. They show that the style of fluvial deposition changed radically between the Neolithic and the Bronze Age at Nea Raedestos in the Anthemous River Valley (Central Macedonia, Greece). Similar radical changes in fluvial style are also reported from Italy in our final paper by Mandarino et al. (2018, this thematic set). This research derives from detailed quantitative and multi-temporal analysis of historical maps, aerial photos, and satellite images (focus 2.4) of the study reach in this Italian river (a tributary of the Po), documenting

channel planform changes since the late nineteenth century. Use was made of GIS software that combined data on channel length, area, width, braiding, sinuosity, lateral migration, activity, and stability to facilitate the identification of patterns of change in the channel planform. Three evolutionary stages were outlined: (1) from 1878 to the 1950s, (2) from the 1950s to the end of 1990s, and (3) from the end of 1990s to present. In the first, the river was able to migrate freely within its floodplain, whereas the second saw channel narrowing and stabilization, a trend reversed in the final stage in which there has been generalized widening in response to the destabilization of surfaces and an increase in bank erosion.

This selection of papers shows that research into fluvial archives over multiple temporal and spatial scales is now routinely applying techniques such as GIS, geophysics, and OSL dating, once considered to be new. GIS allows researchers to broaden their spatial scale away from the site-based study to multiple reaches (e.g., Mandarino et al., 2018, this thematic set; Woolderink et al., 2018, this thematic set) or whole basins (e.g., Anton and Martin, 2018, this thematic set; Soria-Jáuregui et al., 2018, this thematic set), whilst geophysical techniques can improve stratigraphic certainty at a site scale (e.g., Niebieszczański et al., 2018, this thematic set). OSL dating has been crucial in understanding river activity beyond the radiocarbon limit, particularly allowing phases of deposition to be more decisively linked to the climate record (e.g., Avsin et al., 2019, this thematic set; Wang et al., 2018, this thematic set), providing insight into fluvial processes and sometimes overturning previous assumptions (e.g., Olszak et al., 2018, this thematic set).

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