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SwissSed: past, present, and future trends in Swiss sedimentology

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Origins, roots and beginnings

Sedimentology and Switzerland have had a long history together. Some of the names of the many precursors are well known and others less so, but it is certainly not the aim here to carry out any properly documented historical research on the subject. However, with regard as to how sedimentology has evolved since those early roots, it is appropriate to recall the work by Bernhard Studer (1827) linking sedimentology to alpine tectonics; by Amanz Gressly (1838) on outcrop-based facies sedimentology of reefal systems and regional palaeogeography; by François-Alphonse Forel (1892, 1895, 1904) on depositional processes such as density currents, seiche tides and the organic carbon cycle in lacustrine settings; by Jean de Charpentier (1841) and Louis Agassiz (1840) on glaciation and glacial deposits; by Arnold Heim (1932) on rock falls and debris flows; by Arnold Bersier (1958) on fluvial and deltaic systems in the Molasse; and by Augustin Lombard (1956) on the grouping of facies successions into abstract models.

These studies were based on meticulous examination and recording of sedimentary rocks in outcrops, as well as observations on modern depositional environments and processes, linking the present and the past while establishing the similarities but also the striking differences between them. They stand out as having forged major links between facies and depositional processes, establishing depositional models and characterising sedimentary architecture. But most of this was well before the development of sedimentology as a distinct branch of science.

The founding of the International Association of Sedimentologists (IAS) in 1952 is perhaps the best marker of the moment in time when sedimentology was recognised as an independent scientific skills-set, standing on its own, apart from but related to palaeontology, mineralogy and stratigraphy. From this time on, and with the 5th International Congress of Sedimentology being held in Geneva in 1958 (Eclogae Geol. Helv. 1959), Sedimentology became a normal component of teaching at universities in Switzerland.

The development over several decades of novel analytical techniques accompanied the slow but steady growth of student numbers. At the same time, advances in physics, chemistry, biology, engineering and ship-based drilling and exploration (sedimentology and industry have also maintained a strong relationship) brought laboratory studies to the fore in sedimentology. This was most evident where geochemistry and stable isotopes are involved. These laboratory-based studies then became a focus of research in their own right compared to the more classical outcrop and thin-section studies, rather than bringing just a complement to observations made in the field or under the microscope.

And so it was that with the growing numbers of students and staff carrying out sedimentological research, the idea of SwissSed, a loosely structured and informal group of junior staff and graduate students in Switzerland, was mooted in the mid 1980s to share ideas and results between researchers, on their outcrops. However, this emphasis on field-based settings proved impractical, and the group finally consolidated around yearly in-house meetings at the University of Fribourg with presentations given as talks and posters, rather than getting together for field trips.

Philosophy and goal of SwissSed

The original motivations to set up SwissSed with a grass-roots approach, in which the more advanced PhD students and junior staff had the initiative, have not changed over the succeeding years. The first intent was to give students and researchers an opportunity to meet, share, and discuss their work (both methodologies and results) in a small and informal group sharing common interests. Then (from 1992

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onwards) a more practical format of yearly in-house meetings with presentations on student's research in progress was initiated; this provided an opportunity for MSc and PhD students to get used to presenting talks and posters, and to answering questions in a not-too-stressful friendly "family" atmosphere. Progressively, more senior staff and professors took on a coaching role: preparing and presenting talks and posters is still considered good training for students to get ready for the "next-step" to present their results at big, international meetings. Moreover, research by groups composed of students and staff is currently more often considered to be teamwork, with mentoring of newcomers predominating over teaching in a classical sense. In addition to the students' presentations, an established researcher is invited now as a keynote speaker at each meeting to present the latest progress in selected sedimentological topics.

By common consent, Fribourg (where it all started from, but more importantly being central in Switzerland, and making access easy for all) was chosen as the regular venue for the one-day SwissSed meetings, rather than setting up a tour of all the Geoscience departments from one year to the next. The SwissSed meetings are not only visited by students and researchers from all over Switzerland but also from the neighbouring countries (France, Germany, Austria and Italy), evidencing its international breath. SwissSed is by no means a stand-alone initiative. It is complementary and linked to other Geoscience meetings, in Switzerland and abroad, that have sessions devoted to sedimentology, stratigraphy, oceanography, limnology, geomorphology, palaeogeography, palaeoecology, geochemistry, or basin analysis.

Topics of SwissSed presentations: an assessment of results

During the one-day meetings over the last 25 years, the number of talks varied between 9 and 12, and each time 15–25 posters were presented. Figure 1 illustrates the great richness and diversity of these presentations. The graphs are based on the analysis of titles and abstracts from which the predominant ages of the studied sediments, the sediment types, the depositional environments, and the research regions have been identified. In addition, presentations related to ocean and continental drilling (IODP/IDCP) have been listed. The 10th SwissSed Meeting in 2002 was devoted to IODP and ICDP, which explains the hiatus in the graphs. The research methods have been grouped into four general categories but overlaps of course are common. While sedimentology in its widest sense is the principal research domain, combinations with stratigraphy, palaeontology, palaeoecology, oceanography, and structural geology are common but do not appear in this figure.

Despite the strong variability throughout the years, some trends are visible. Studies dealing with Mesozoic sedimentary rocks become less frequent while those dealing with the Pleistocene, Holocene and Recent are increasing. Carbonates dominate slightly over siliciclastics but both topics maintain a constant research interest. Microbialites also display a constant trend but on a lower level, while interest in phosphatic, siliceous, manganese-bearing, and organic-rich sediments slightly increases. Concerning the general depositional environments, oceans are dominant but become somewhat less attractive, while fluvial, terrestrial, and lake studies increase.

At the beginning of the SwissSed meetings, studies in Switzerland were dominant but in the meantime have lost out to research areas outside Europe. Presentations related to ocean and continental drilling are regularly present and testify to the active involvement of Swiss sedimentologists. The methods are clearly dominated by facies analysis (petrography, microfacies, SEM, CT-scans, sedimentary structures). Sequence- and cyclostratigraphy had a high at the 12th Meeting in 2004, while isotope geochemistry was well represented during the 16th Meeting in 2008. Modelling and experimental work maintain a low level.

Figure 1 demonstrates that sedimentological research in Switzerland covers all relevant domains and is strongly field-based (facies analysis being much more important than modelling and experiments). While new research areas are opened up and new methods developed, the classical approaches are not forgotten. The young researchers presenting talks and posters at the SwissSed meetings thus are well positioned in the mainstream and competitive on a high international level.

Perspectives

While the intention remains to keep SwissSed an informal, "small is beautiful" grass-roots affair, there is a clear desire to promote enthusiasm and pleasure in doing research, to promote the quality of research and science communication and to provide an environment to attenuate the administrative pressure of "publish or perish". This goes together with encouraging a "feed-forward" philosophy; emphasizing what new can be achieved by the direct application of recently acquired knowledge or skills, rather than to give feedback just evaluating efficiency or performance.

The needs to keep up with international research trends, but at the same time not lose the classical sedimentological skills are major threads that link one meeting to the next. Other strong drivers are to promote both fieldwork- and

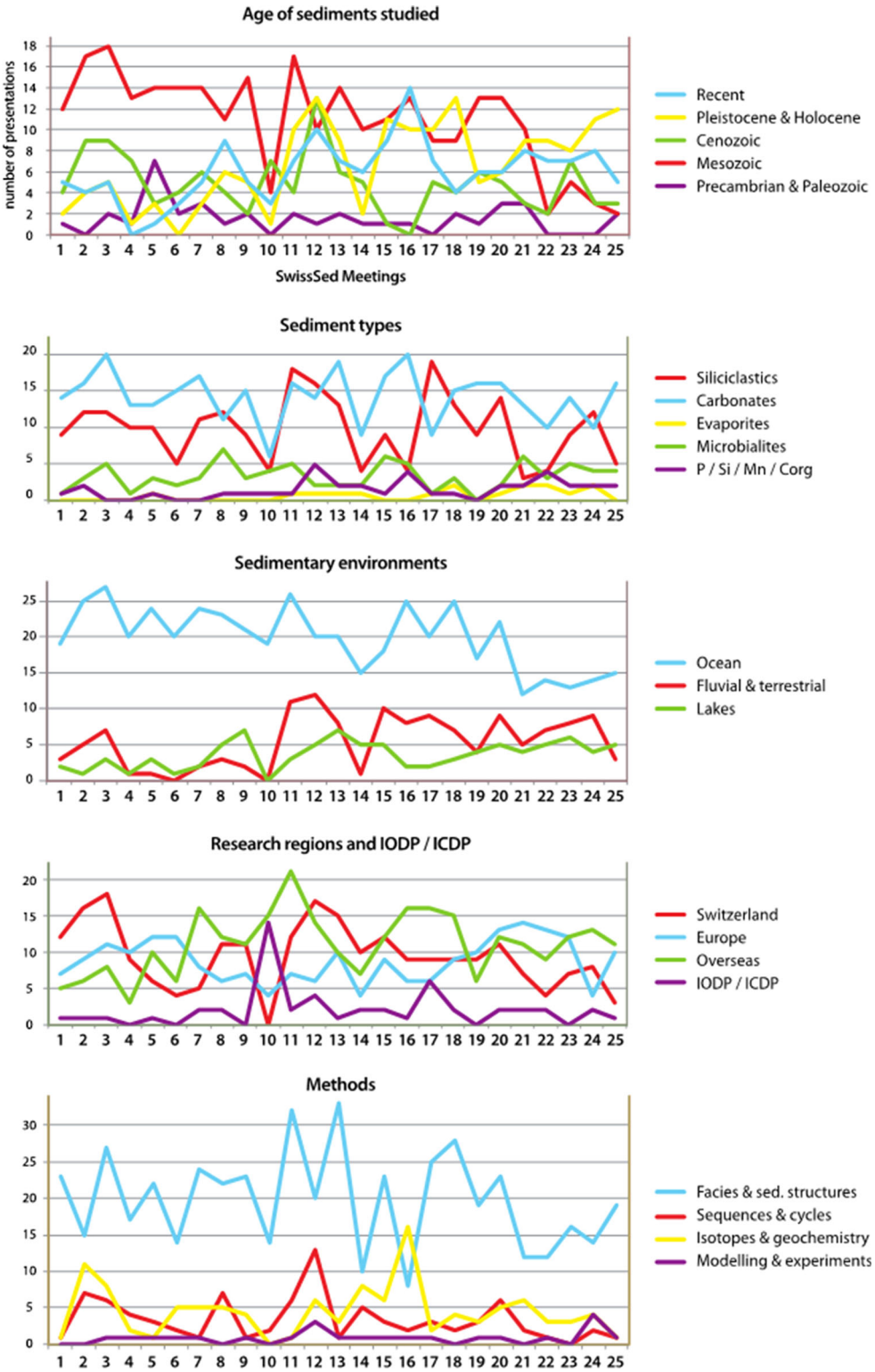

Fig. 1 Sedimentological research in Switzerland: SwissSed talks and posters, 1992–2017

labwork-based studies (not ranking one above or below the other) and to emphasize the complementarity and genuine necessity of both "top-down" and "bottom-up" investigation (to include both broader views and synthesis as well as the analytical, somewhat "tool-dependant", detail). Finally, these reasonably successful efforts to promote active networking between young researchers from Swiss university departments could be expanded by forging links to involve young researchers in the same field but coming from neighbouring countries or even further afield.

The present volume reflects the result of 25 years SwissSed celebrated during the 25th SwissSed Meeting, which took place on the 25th of February in Fribourg . This SwissSed jubileum edition brought together with the encouragement and skill of Silvia Spezzaferri (University of Fribourg) in collaboration with the SwissSed Committee, Flavio Anselmetti (University of Bern), Elias Samankassou (University of Geneva), Vincenzo Picotti (ETH Zürich) and Anneleen Foubert (University of Fribourg), is a good illustration of the current state of SwissSed with regard to the exchange of ideas and results across universities. Although it is far from reflecting the full range of sedimentology carried out in the country, it does portray a healthy and productive sector of the Swiss geosciences community.

Content of the present volume

In this special issue of the Swiss Journal of Geosciences emphasis is placed on the young generation of scientists. The enthusiasm of young scientists has greatly contributed to celebrate the 25th anniversary of SwissSed that has increased its popularity through years of dedicated sedimentological and micropaleontological research in Switzerland and adjacent European countries. The special issue is divided according to topics spanning from Swiss sedimentology and limnology to international studies on cold- and warm- carbonate factories, and to research related to the International Ocean Discovery Program (IODP) and International Continental Drilling Program (ICDP).

Swiss sedimentology and limnology

An important problem in Switzerland is the storage of radioactive waste. The article of Lauper et al. (this volume) addresses the Opalinus Clay, the identified potential host rock for radioactive waste disposal. This succession consists of mudstones accumulated in a shallow epicontinental shelf sea during the late Toarcian to early Aalenian. The innovative research of Lauper and colleagues consists in the quantification, validation and refinement of the lithofacies classification, sedimentary petrographic descriptions at micro- and macro-scale, geophysical and geochemical core logging, and organic matter quantification. This high-resolution, multi-proxy facies analysis revealed for the first time the existence of small-scale, intra-facies heterogeneity within the Opalinus Clay.

Lu et al. (this volume) analyze the geochronology and geochemistry of detrital zircons of late Palaeogene syntectonic volcanic products from the northern Alpine foreland basin in the South-Alpine hemipelagic basin to evaluate their temporal and genetic relationships with potential volcanic sources. The results suggest that the volcanic materials in the Taveyannaz Formation come from surficial extrusions and dykes along the Peri-Adriatic fault between 41 and 29 Ma (late Eocene to early Oligocene). This study provides new ages for the Taveyannaz Fm. and allows identifying the different Peri-Adriatic magmatic systems as zircon sources, providing evidence for their long-distance fluvial transport to the basin margins.

The article by Reisdorf et al. (this volume) presents a case study demonstrating synsedimentary tectonics in a slowly subsiding marine depositional area within an epicontinental basin as part of the Germanic Basin or Central European Epicontinental Sea during the Early Jurassic. They demonstrate that isopach and facies patterns provide clear evidence of differential subsidence, while faults that formed in the basement during the late Palaeozoic became reactivated during the Early Jurassic and enhanced hydrothermal activity as documented by chronometric ages of veins and mineral alterations.

The article of Looser et al. (this volume) focuses on the investigation of the Triassic-Jurassic boundary in sedimentary sections outcropping at the southern margin of the Central European Basin that are today located in northern Switzerland. Organic carbon, nitrogen isotopes in combination with palynofacies analyses allow to correlate the isotopic shift in the $\delta^{13}C_{TOC}$ with the GSSP section at Kuhjoch (Tethyan realm), with other European sections and, with the perturbation of the global carbon cycle observed worldwide.

The biostratigraphy of the Gurnigel and Voirons nappes (the Voirons-Wägital complex) has been in debate for a long time. Recent studies based on planktonic foraminifera have attributed the Voirons flysch to the middle Eocene to early Oligocene. Ragusa et al. (this volume) re-examine planktonic foraminifer biostratigraphy from the Gurnigel and Voirons nappes, confirm the ages based on nannofossil stratigraphy, and attribute the Voirons flysch to the early Eocene (planktonic foraminiferal zone P7) and to the middle Eocene (planktonic foraminiferal zone P12). Therefore, a re-evaluation of the palaeogeographic origin of the Voirons-Wägital complex and of the sedimentation history of these flysch deposits is now needed.

The Upper Jurassic carbonate rocks represent an important potential reservoir for geothermal energy in the Geneva Basin (Switzerland and France). Makhloufi et al. (this volume) investigate the horizons affected by dolomitization from these rocks outcropping in the Geneva Basin. Their results highlight early dolomitization, in the form of replacement dolomite, and propose a reflux model for dolomitization rather than the mixing-zone model of earlier works in this area. These results are a first step towards a better understanding of the diagenetic history of the Upper Jurassic in the Geneva Basin.

In the long-lasting tradition of Swiss limnology, the research of El Kateb et al. (this volume) proposes a relatively new approach to continuously trace the water masses in Lake Murten, located in the Lake District in western Switzerland. The investigation in collaboration with the Environmental Service of Fribourg involves the deployment of a Lander system conceived and built at the University of Fribourg equipped with sensors to measure water temperature and dissolved oxygen at ultra-high resolution (30 s interval). The research reveals a clear correlation of the lake temperatures with wind speed.

Carbonate factories and adjacent basins

A new morphospecies of planktonic foraminifera from the Maldivian region (drilled during IODP Expedition 359) is described in Steinbank et al. (this volume). The identification of *Globigerinoides eoconglobatus* n. sp. is based on robust morphological and morphometrical evidence as well as on its stable oxygen and carbon isotope values. The phylogeny of this morphospecies is traced from its ancestor *Globigerinoides obliquus* to its descendant *Globigerinoides conglobatus*. The authors also show that relative abundances of *G. eoconglobatus* n. sp. and *G. conglobatus* are linked to glacial-interglacial stages.

Coletti et al. (this volume) present the first investigation of Large Benthic Foraminifera (LBF) from IODP Hole 1468A (drilled during IODP Expedition 359, Maldives). They identify in this drill hole two intervals characterized by shallow-water LBF (in the late Oligocene and middle Miocene, respectively) that are correlated with planktonic foraminifera and calcareous nannofossils. The taxonomy of LBF is achieved by innovative micro-CT scan techniques.

A Sinemurian coral-microbialite patch reef documented in the southern part of France (Le Perthus) is the main focus of the research of Bonvin et al. (this volume). Based on the detailed description of the outcrop and its bio-components (including corals, sponges, bivalves, serpulids) they classify this reef as a coral-microbialite bioconstruction (with microbialites as main framebuilder) that developed in a shallow, mixed siliciclastic-carbonate inner ramp setting in a possibly mesotrophic environment. This investigation also provides important information about coral assemblages after the Triassic/Jurassic boundary, characterized by profound biotic and environmental changes expressed in a dramatic decrease in marine faunal diversity.

Ostracod assemblages from the cold-water coral ecosystem in the Melilla Mound Field (Alboran Sea) are presented in Pirkenseer et al. (this volume). The authors trace the distribution of these crustaceans from the Holocene to the Present with a special focus on comparing their abundances with those of benthic foraminifera and to identify their potential correlation with substrate and sedimentary facies. Taxonomic notes with quantitative data on the valves of selected ostracod species and SEM images are also an important component of this article.

The investigation of Fentimen et al. (this volume) targets the Moira Mounds, a cluster of cold-water carbonate mounds documented in the Porcupine Basin (off-shore Ireland). They describe the distribution patterns of living (Rose Bengal stained) benthic foraminifera coupled with those of dead specimens in the sediments to evaluate the response of these organisms to environmental variability and taphonomic processes. The results show that they can be only classified based on presence vs absence of corals instead of distinctive sedimentary facies. A new model for foraminiferal distribution in small-sized carbonate mounds is proposed.

Holocene and Recent sedimentology

Surdez et al. (this volume) investigate the Franchthi Cave, bordering Kiladha Bay in Greece, which has been occupied by humans from $\sim$ 40'000 to $\sim$ 5'000 yr BP. Using petrophysical, sedimentological, geochemical, and chronostratigraphic methods, coupled with the discovery of pottery fragments, the authors document for the first time the evidence that Neolithic people were present in this dynamic landscape interacting with a migrating coastline. This important discovery opens the opportunity to prove the presence of Neolithic villages in the region that eventually became buried under marine sediments.

The article of El Kateb et al. (this volume) focuses on the environmental characteristics of the Djerba lagoon. This lagoon represents a unique environment on Djerba Island, which is one of the most famous touristic poles in Tunisia. The study concentrates on water and sediment geochemistry and benthic foraminiferal assemblages. The analyzed biotic and abiotic parameters reflect a transitional environment from hypersaline (in the inner part of the lagoon) to normal-marine conditions (close to open sea) and a salinity gradient, which has a relevant impact on seagrass and benthic foraminiferal distribution.

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