MONDAY, 18 AUGUST — 13:30 — R380 — PLENARY LECTURE

Sedimentary Records of the Ice Sheet Behavior During Past Warm Intervals: An Ocean Drilling Strategy

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Polar ice is an important component of the Earth Climate System, affecting global sea level, ocean circulation/heat transport, albedo, and marine productivity, among other. Despite of their relevance, polar areas are largely unsampled and as a result the correlations between: 1) the records of temperature, CO_2 and ice sheet volume (and equivalent sea level), and 2) the mechanisms responsible for glacial-interglacial cycles (i.e., role of atmospheric CO_2) have not been yet fully elucidated.

The study of ice cores retrieved from the polar ice cap has afforded major breakthroughs in understanding natural climate variability over the last 800,000 years. However, at no time during the last 1 million years (m.y.), CO_2 concentrations in the atmosphere reached the 400ppm we experience at present. In fact, the lower values of atmospheric CO_2 and temperatures forecasted for the end of this century (IPCC, 2013) have not been experienced on our Planet for over 4 m.y. (i.e. before the Arctic ice sheets formed), and the higher forecasted values since before the ice sheets in Antarctica formed. Antarctica and its margins are therefore key locations from where to retrieve the long-term sediment records needed for a detailed understanding of how ice sheets responded to past climate forcings.

During the last decades ocean drilling in Antarctica (e.g., DSDP, ODP Legs 178, 188, IODP Expedition 318, ANDRILL and SHALDRIL) has revealed regional information about sea ice and ice sheets development and evolution. Although these records are still sparse and incomplete, they are complimentary and allow for a preliminary assessment of the variations between different ice sheet sectors. Additional records are needed if we are to address key knowledge gaps about the role of polar ice in climate change, targeting questions such as: how do ice sheets respond to warmer than present conditions (elevated CO_2 and temperatures); ice-ocean interactions (and equivalent sea level rise); timing of events; rates of change; tipping points; regional variations; and northern vs. southern hemispheres (in phase or out-of-phase) variability. This data is critical to provide constrains to sea-ice and ice sheet models, which are the basis for forecasting the future of the cryosphere in a warming world.

A multiplatform, multinational strategy has been developed within the SCAR PAIS (Scientific Committee for Antarctic Research-Past Antarctic Ice Sheet Dynamics) Program to collect sediment records from ice-to-abyss transects in vulnerable areas of the Antarctic ice sheets. With this strategy, PAIS aims to improve our understanding of the sensitivity of the Antarctic Ice Sheets to a broad range of past climatic and oceanic warm conditions (i.e., “greenhouse” climates, times of more recent warming and ice sheet retreat during glacial terminations). Ocean Drilling is key to this strategy. The ECORD Mission Specific Platforms will allow access to coastal and ice-covered areas, and will allow for higher recovery of glacial sediments. Ship-based drilling (i.e., JOIDES *Resolution*-type) is required for obtaining long-term high-quality paleoclimate and paleocenanographic records in deeper, ice-free areas of the margin. These records will be linked with ice core and continental records of past ice sheet behavior and sea level, yielding an unprecedented view of past changes in ice sheet geometry, volume, and ice sheet-ocean interactions.

TUESDAY, 19 AUGUST — 13:30 — R380 — PLENARY LECTURE

Earth's Deep-Time Insight into Our Climate Future

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Earth has two fundamentally different climate states—a cool 'icehouse' state characterized by the waxing and waning of continental-based ice sheets at high latitudes, and a 'greenhouse' state characterized by much warmer temperatures globally and only small—or no—ice sheets. Although Earth has been in an icehouse for the past 34 million years, warmer greenhouse conditions have been the 'typical' climate state of the past half billion years. At the current rate of global C emissions, atmospheric CO_2 is projected to increase within this or the following century to levels last experienced on Earth prior to the onset of our current glacial state. Insight into how the Earth system will function in such an evolving and high CO_2 environment uniquely resides in the deep-time geologic record — the only integrated archive of the full spectrum of climate-related processes, feedbacks, and complex climate-ecosystem interactions in the earth system.

The paleoclimate record of the recent past unquestionably provides a critical baseline against which future climate change can be assessed given its resolution and precision. However, it captures only part of the known range of climate phenomena as it has been derived from a time dominated by low (30% lower than today) and relatively stable atmospheric CO_2 and bi-polar glaciations. Study of the deep-time geologic record reveals climate change in the past that was at times far more dynamic than suggested by reconstructions of the past few hundred thousand years and further elucidates feedbacks in the climate system that have operated differently in the past. Data-climate model comparisons of past warm periods further suggest that the magnitude and duration of climate change and the CO_2 levels at which critical climate and ecological thresholds could be crossed may well be underestimated by current climate projections. This presentation will place current and projected levels of atmospheric CO_2 into a deep-time context and use three examples of past major transitions to document the dynamic nature of past global warmings during both ice- and green-houses, evidence for atmospheric CO_2-climate coupling throughout Earth history, and to illustrate climate and ecological thresholds of greenhouse-gas forced climate change.

THURSDAY, 21 AUGUST — 13:30 — R380 — PLENARY LECTURE

Sedimentology Frontiers from Earth to Mars: Dunes, Deformation, and Diagenesis

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An enticing challenge of sedimentology is applying our knowledge to new exploration settings, using clues and proxies to deduce the processes of sedimentation. Mars has held our interest since ancient times, but now through new technologies and instrumentation advances we have the ability to scientifically explore the Red Planet at unprecedented scales. Studies of sedimentary environments on Earth are critical, as terrestrial analogs help us interpret depositional and diagenetic processes, as well as determine where habitable environments for life might exist.

Three comparative sedimentary examples of Earth settings show remarkable similarities to recent satellite and rover imagery from Mars:

1. Ergs on Earth are globally important reservoir units for both hydrocarbons and water. Mars has spectacular dune forms and dust devil tracks, reflecting the ubiquitous nature of eolian processes shaping the surface of Mars. Porous dune sediments record the interactions of the atmosphere and the surface, and have the potential to hold hold fluid volumes or cement mineralogies in the subsurface.

2. Soft-sediment deformation with varying expressions (e.g., contorted cross bed sets, massive sandstone layers, and clastic injectites) occur in eolian units. These can provide clues to past water table conditions and the susceptibility of the sediments to strong ground motion. Weathering patterns in these sandstones can reflect differences in the massive versus cross-bedded host rock textures.

3. Finally, Earth sandstones commonly show different colors of iron oxide cementation reflecting the mobility of iron in the Earth's crust. These diagenetic records of past fluid flow histories provide clues about reservoir properties for aquifers and hydrocarbons. Is diagenesis a biogenic as well as a physical process? Many diagenetic relationships suggest a very strong link.

Mars is an exciting frontier for sedimentology, offering opportunities for serendipitous discoveries of what might exist within its sedimentary layers and surface landforms.

FRIDAY, 22 AUGUST — 13:30 — R380 — PLENARY LECTURE

Sea Level Rise: Recent Past, Present and Future

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It is now well established that the Earth‘s climate is warming and that the main reason is the accumulation inside the atmosphere of green house gases produced by anthropogenic fossil fuel combustion and change in land use (IPCC AR5, 2013). Global warming has already several visible consequences, in particular increase of the Earth's mean temperature and of ocean heat content, melting of glaciers, and ice mass loss from the Greenland and Antarctica ice sheets. Ocean warming causes thermal expansion of sea waters, hence sea level rise. Similarly, land ice melt that ultimately reaches the oceans, also causes sea level to rise. Sea level rise induced by global warming and its impacts in coastal zones has become a question of growing interest for in the scientific community, and the media and public. In this presentation, we summarize the most up-to-date knowledge about climate change and associated impacts on ocean warming, land ice melt and sea level rise. We also present sea level projections for the 21st century under different warming scenarios, highlighting the regional variability that superimposes the global mean rise. Finally, we address the question of the sea level rise impacts. We discuss the many factors (due to natural phenomena and direct anthropogenic forcing) causing adverse effects in coastal zones and show that climate-related sea level rise will generally amplify the vulnerability of these regions.

THURSDAY, 21 AUGUST — 17:05 — R380 — SORBY MEDAL

Unlikely carbonates; they are so cool!

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The most improbable carbonate sediments and rocks are those that form in the cold, frigid, and freezing ocean well outside the soft, warm, sunlit, waters of the tropics. When the IAS was born some 60 years ago and until recently such deposits were barely mentioned – all limestones were obviously tropical! Now temperate and polar limestones are an integral part of mainstream sedimentology. How has this happened?

It was intuitively obvious, even in the 1800's, that limestones were tropical creations and so we happily went to modern environments in the Caribbean, the Persian Gulf, and the Pacific to understand them. Although cool water calcareous sediments had been long described the first inklings of serious cool-water extratropical limestones came from Cenozoic successions in New Zealand, islands surrounded by shelves covered with almost identical cool-water calcareous sediments. But so what? This was far away whereas a new succession of Phaneroizic limestones was daily being interpreted as tropical and correlated with burgeoning new information on warm water deposits. The breakthrough came simultaneously on several fronts about 25 years ago; 1) it was realized that southern Australia was an enormous area of cool-water carbonate deposition, vast carbonate banks of ancient cool-water carbonates were now possible, 2) the southern hemisphere, as well as the Mediterranean, had extensive Cenozoic temperate carbonate deposits, and 3) some Paleozoic limestones looked astonishingly like these Cenozoic rocks. The realization began to sink in that cool-water limestones had been part of the carbonate world all along.

Increased research has since resulted in a rush of discoveries; 1) cool-water seagrasses are prolific sediment factories whose carbonate productivity exceeds that of similar tropical marine angiosperm, 2) macrophye (kelp) factories are significant carbonate factories, especially in cold high latitude marine environments, 3) cool marine carbonates can occur adjacent to marginal marine peritidal evaporite-dolomite environments, 4) bryozoan-sponge reef mounds, long thought to be extinct Paleozoic buildups, grow in modern cool-water upper slope environments, 5) high latitude, polar deposits unexpectedly form at the coldest and not the warmest of times, 6) extensive seafloor dissolution is occurring in the temperate neritic zone well above the lysocline, 7) diagenetic implications of cool-water calcite-only sediments are profound, there is insignificant early meteoric cementation thus pathways of burial diagenesis are profoundly different and those of warm-water carbonates. Cool carbonates have come of age and perhaps the most important aspect is that they provide is a framework against which to compare the warm water deposits and thus a more realistic vision than ever before of ancient and very ancient seascapes.

Our evolving knowledge of neritic carbonates has taken two totally different intellectual pathways. First, understanding of carbonate sedimentation evolved differently in the two hemispheres. Acceptance of cool-water carbonates came largely from the southern hemisphere because there were no vast cool-water systems in the north – too much dirt from recent glaciation. Second, limestones were so fossiliferous and so intuitively tropical, thus research focused on the tropical seafloors - the rock record drove research on modern sediments. By contrast cool-water carbonate sediments were long known but not equivalent limestones - modern sediments drove research into ancient rocks. We are students of the earth but we should never forget that we are also prisoners of our personal experience.

THURSDAY, 21 AUGUST — 17:50 — R380 — WALTHER MEDAL

Flood record in marine sediments

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River flood-generated turbidity currents (hyperpycnal flows) form at mouths of rivers at a frequency varying from one event per year, to one event every millennium or so. Particular geological environment (presence of easily erodable sediment) and climate (long wet season or monsoon) are the main causes for exceptional high-frequency of hyperpycnal flows (south-Asian rivers). Hyperpycnal floods generally have a meteorological origin, but catastrophic hyperpycnal floods can also occur due to dam outburst in the catchment area of a river. In some cases, catastrophic floods are associated with earthquakes or volcanic activity.
This talk focuses on the processes, character and significance of flood-related turbidity currents and their deposits (hyperpycnites) in the geological record based on selected examples from modern environments, outcrops, sediment cores and seismic reflection profiles.
Excess density when compared to density of the ambient water in the receiving basin allows the transport along the basin floor. Most of the suspended sediment supplied to the river mouth is transported during flood-generated flows, because: (1) hyperpycnal flows form during major flood events, and (2) for suspended load-dominated hyperpycnites, the rating curve of a flood event is represented by a power law relationship between discharge and load.
Consequently, flood-generated deposits can represent a significant part of basin-fill in basins supplied by a siliciclastic source. Flood-generated flows transport mainly fine-grained suspended particles, but also a significant amount of sand as bed load. Classical hyperpycnal-flow deposits (hyperpycnites) are located seaward of 1) dirty small-sized mountainous rivers, 2) cleaner rivers that are occasionally subjected to landslides or bank-failure in areas of earthquake activity or jökulhlaups, or lahar events and 3) other rivers through density cascading and reconcentration processes. Taking into account reconcentration, as much as 84% of the world river can generate hyperpycnal flows with initial concentration at the river mouth as low as 5 kg m^{-3}.
Classical hyperpycnal deposits (hyperpycnites) are characterized by a coarsening-upward basal unit formed during the rising limb of the flood (waxing flow) and a fining-upward upper unit formed during the falling limb of the flood (waning flow). During major floods the basal part may be eroded. Hyperpycnites collected on the prodelta of the Rhône River show that geochemistry can help to the diagnosis of flood-related deposits. Flood sequences are enriched with continent-supplied elements (Si, Ti). The deposit sequences also show enrichment in organic matter related to the abundance of plant fragments.
This analysis shows that (1) hyperpycnal flows can generate deposits in many deep-sea environments; (2) These frequent, long duration, quasi-steady flows are good candidates to explain canyon and meandering channel-levee systems and more distal, basinal fan lobes both in marine and lacustrine environments. (3) Because of the duration of flood-generated turbidity currents, a distinguishing feature of hyperpycnal flows is long distance that sand can be transported despite the smaller proportion of sand relative to many classical slide-induced turbidity currents. (4) Because they are related to floods, frequency and thickness of flood,-deposits represent a good deep-sea marker on climatic change across continents. This is particularly the case of major flood deposits that formed during the dismantlement of the North-American ice sheet at the end of the last glacial period (Lake Bonneville or Lake Missoula floods).

THURSDAY, 21 AUGUST — 17:55 — R380 — YOUNG SCIENTIST AWARD

Shaken and Stirred: Extreme events archived in the sedimentary records of lakes and continental margins

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The study of insitu-deformed, remobilized and redeposited marine and lacustrine sediments affected by geological extreme events such as subaquatic landslides, earthquakes and tsunamis aims at better understanding causes and consequences of such geohazard processes. Earthquakes and tsunamis induce ground shaking and hydro-dynamic effects, respectively, which induce transient dynamic stresses acting on unconsolidated sediments on our lake’s and ocean’s floor, triggering sediment instability and remobilization and leaving characteristic sedimentary deposits and structures in the sedimentary record after the transient stresses cease. The sedimentary record therefore can be used to investigating past occurrences and to make inferences of intensities of such extreme events in the geological past.

Here, I present some highlights of more than 10 years of my research studying subaquatic mass movement deposits and its relation to tectonic processes and earthquakes in contrasting seismotectonic environments: The study areas range from (1) lakes in the intraplate region of Central Switzerland, where characteristic pattern of subaquatic mass-movements deposits are used to reconstruct past earthquakes in the last 15’000 years; and (2) active subduction zones offshore Japan, where (2a) Integrated Ocean Drilling Program (IODP) drilling allows for studying more than 1 Million years of submarine landslide history in the actively deforming Nankai accretionary prism, and (2b) where the most recent magnitude 9 earthquake and devastating tsunami in 2011 (Tohoku-oki event) provides a unique opportunity to investigating the sedimentary fingerprint and how it will be preserved in the geological record of the Japan Trench

I present data ranging from margin- (basin-) wide geophysical imaging of the sea/lake- and subsea-/lakefloor, to sedimentological, geotechnical, geochemical and X-ray computed tomography (X-CT) analyses of cores and scanning electron microscopy (SEM) imaging micro-scale structures and features. This aims at studying extreme event deposits resulting from subaquatic mass movements on various scales and deciphering sedimentological, geotechnical, magnetic, biological and/or chemical signatures preserved in the deposits that may allow us to reconstruct transport dynamics, preconditioning and triggering mechanism of subaquatic mass transport and slope instability initiation, respectively. The integration of data and results from the three presented case studies, will allow for discussion if, how, and in which setting, we can use the sedimentary record of lakes and continental margins as natural seismographs for reconstructing the earthquake history towards better characterizing the seismotectonic setting and better understanding long-term recurrence patterns.

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TUESDAY, 19 AUGUST — 19:00 — R380 — PUBLIC LECTURE

GEothermie 2020 : mieux connaître le sous-sol genevois pour réinventer l'eau chaude !

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Les calcaires blancs visibles sur les crêtes jurassiennes ou sur les flancs du Salève recèlent des trésors méconnus. Ils nous renseignent sur l'histoire ancienne de notre région et nous apprennent, entre autre, qu'une mer chaude et peu profonde, jalonnée d'iles peuplées de dinosaures, recouvrait la région il y a environ 140 millions d'années, bien avant que les Alpes et le Jura ne se forment.
Ces mêmes couches calcaires plongent sous le bassin genevois où ils pourraient être le siège d'une autre richesse : de l'eau chaude en grande quantité. De quoi fournir jusqu'à 2/3 des besoins de chaleur de l'agglomération genevoise ! En effet, la chaleur de la terre – environ 35°C gagnés par kilomètre d'enfouissement - combiné avec un sous-sol gorgé d'eau semblent offrir de magnifiques possibilités pour que la géothermie soit l'énergie de demain à Genève.
Cependant, le sous-sol genevois est encore très mal connu et toutes les couches géologiques ne renferment pas de l'eau en quantités équivalentes. Pour exploiter cette richesse de manière durable et intelligente, il va falloir le cartographier finement, tirer le maximum d'enseignements des données existantes, et profiter des sciences géologiques pour identifier les secteurs les plus favorables.
L'Etat et les SIG ont lancés le programme de prospection et d'exploration du sous-sol GEothermie 2020. Les géologues, paléontologues, sédimentologues, géophysiciens et géochimistes, par leurs compétences et grâce à des outils d'analyse modernes, vont permettre de préciser la nature du sous-sol genevois et de réduire les risques d'échecs de futurs projets géothermiques. Le département de géologie de l'Université de Genève, spécialiste en sédimentologie et en géologie de réservoirs, est mandaté par SIG pour accompagner ce projet et y mettre toutes les compétences spécifiques requises.
Est-ce que la géothermie fonctionne ? Quelles sont les techniques de prospection et d'exploration qui seront utilisées ? Comment imager le sous-sol à plusieurs kilomètres de profondeurs ? Quels enseignements tirer des montagnes qui nous entourent ? Qu'est-ce que la sédimentologie ? Autant de questions qui seront abordées pour expliquer comment passer de l'eau chaude des mers du Jurassique à l'eau chaude de la Genève de demain !