A geochemical-mineralogical approach for the reconstruction of past flood events

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The increasing frequency of extreme flood events is a subject of debate for many years and it is speculated that this is a possible consequence of climatic change and/or recent river regulation operations. However, a well-founded discussion on the cause(s) of extreme flood events requires a more accurate record of their frequency and magnitude till a more distant past.

In looking for an adequate approach for the reconstruction of paleo-flood events we act on the assumption that the specific hydrological conditions during high water levels will entail a change in the grain size of the transported suspended matter and consequently, will also cause a change in its mineralogical and geochemical composition due to varying sources. Preliminary investigations on the suspended load of the River Rhine show that the amount of particles transported during a flood is not only much higher, but the grains are also larger in size and hold other geochemical-mineralogical features as compared to such particles transported during normal water levels. Indeed, it could be shown that the particulate matter transported during inundations is marked by a higher portion of coarse carbonate and a lower portion of fine grained fraction enriched in iron oxides.

During a flood event the suspended load is deposited on the floodplain, forming up to several centimetres thick accumulations. This material was cored on the floodplains of the Rhine close to Elchesheim-Illingen and on that of the Danube at Pfatter, by carrying out several short (up to 3 m deep) drillings which were sampled every centimetre. The relationship among the geochemical and mineralogical parameters was studied by means of factor analysis.

Results from the Rhine floodplain sediments clearly indicate a connection between individual mineral phases and specific grain size ranges. Thus the fraction < 20 µm correlates significantly with the iron oxide content, the grain size fraction 20 to 100 µm with the carbonate content, while the fraction > 100 µm is correlated with the amount of the siliciclastic components. It still has to be verified, whether the dominance of the fraction 20 to 100 µm during flood events is a local feature or if it can be extended also to larger sections of the Rhine.

These results demonstrate that a systematic and detailed study of the distribution of grain size and geochemical-mineralogical features of flood plain sediments may yield valuable insights in the occurrence of past flood events. The age of the sediments and hence the inundation can be dated e.g., by means of thermo luminescence and thus information could be obtained about the frequency and magnitude of extreme flood events far beyond historical records.

The age of the earliest continental crust and onset of plate tectonics

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We present bulk Hf and Pb isotope data obtained by solution chemistry and, respectively, MC-ICP-MS and ICP-MS for 60 new leached single Jack Hills zircons determined by SIMS spot analysis to be between 3.9 and 4.35 Ga in age. We also present bulk Pb isotope data corresponding to the MC-ICP-MS Hf isotope data of Harrison *et al*. (2005). Because abundant ^{235}U was still extant during the Hadean, the ^{207}Pb/^{206}Pb ratio of radiogenic Pb varied extremely fast in the young Earth. Measurements with even modest precision thus provide reasonably accurate estimates of the age of old samples, provided adequate correction for common and contaminant Pb is applied. For this we used the strong correlation between ^{207}Pb/^{206}Pb and ^{208}Pb/^{206}Pb (r^2= 0.985) on the assumption that Th/U of concordant zircons vary within only a narrow range (0.7±0.2). If so, the Pb isotope data show that most of the zircons have bulk ages of 4.08±0.15 Ga with a small tailing to younger ages and that no analyzed grains have bulk Pb-Pb ages older than 4.25 Ga. None of the zircons qualified by SIMS to be older than 4.3 Ga have bulk Pb isotope values consistent with such high ages, indicating these ages are overwhelmed by younger U-Th-Pb domains. Although the majority of the ICP-MS bulk Pb ages are in agreement within ~100 My with the associated SIMS spot ages, the former portray a younger and more restricted age range of Jack Hills zircons than the latter. However, this does not affect the conclusion reached by Harrison *et al*. (2005), based on Jack Hills zircon Hf isotope systematics and reinforced here by our new Hf isotope data (which are equally heterogeneous and exhibit both negative and positive epsilon values), that at least some continental crust began forming very early. Assuming a ^{176}Lu/^{177}Hf ratio of 0.015, typical of sediments and granites and low enough for our age assessments to be minimum rather than maximum estimates, and that all bulk zircon ages are ~4.1 Ga, the CHUR and DM model ages for the source (protolith) of the granites hosting the Jack Hills zircons are, respectively, 4.3-4.4 and 4.4-4.5 Ga. Because granites are the hallmark of modern plate tectonics, our Jack Hills data strongly suggest this process was active by at least 4.1 Ga. Demonstrating that it started even earlier requires independent evidence that the protolith itself was also granitic, an enticing interpretation given the heavy oxygen of a significant fraction of the Jack Hills zircons, their low cystallization temperatures (680±25°C), and the nature of their mineral inclusions.

References

Harrison, T.M., Blichert-Toft, J., Müller, W., Albarède, F., Holden, P. and Mojzsis, S.J., (2005), *Science*, **310**, 1947-1950.