

However, *soil samples* (green land and forest) of the same areas indicate negative trends for both cadmium and lead with the water adsorption but showed positive

trends with the dissolved (mobile!) organic matter in both cases.

Reading the Paleoclimate Record of Lunana: Quaternary Research and Glacial History in the Bhutan - Himalaya

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Lunana is a heavily glaciated area in the northwest of Bhutan with recurrent catastrophic glacial lake outburst floods. This work comprises the first quaternary insights into a unique glaciated landscape of the Himalaya Range, hitherto only described by A. Gansser (1983).

A succession of Pleistocene to Holocene moraine-complexes and ice marginal deposits excellently documents the decay of a huge ice stream net and thus the transition from glacial to interglacial climatic conditions in the Lunana area.

As remnants of Pleistocene glaciation an erosional trimline, thick sequences of lodgement till and huge lateral moraines, raising 500 m above the valley bottom, are preserved. The process of oversteepening valley slopes by carving Pleistocene ice flow leads to impressive U-shaped valley geometries.

A loess covered terminal moraine complex at an altitude of 4100 m asl. has been interpreted as a Late Glacial stage (THANZA STAGE). A glacier advance of 19 km (relative to the watershed boundary) is accompanied by an approximate ELA – depression of 300 m (relative to the recent situation). Ongoing OSL dating of this Pleistocene remnant will help to understand the timing and spacing of local glacier fluctuations, thus revealing the climatic change for this part of the Eastern Himalaya at the Pleistocene/Holocene transition.

The Holocene and Neoglacial moraines are restricted to the recent glaciers. The Raphstreng glacier shows particularly well developed multiple terminal moraines and multigenetic lateral moraines, indicating repeated glacier advance and decay at the scale of a few

kilometers during the last 10 000 years. Special attention has been paid to the multigenetic Holocene lateral moraines. Their formation is characterized by dumping of supraglacial debris with each glacier advance. Ongoing ¹⁴C dating of buried paleo-soils within these lateral moraines and in similar stratigraphic positions could help to reconstruct Holocene glacier fluctuations in detail.

Since the Little Ice Age, continuous vertical ablation of the glacier tongues occurred, since 1950 supraglacial lakes merge together and glacier tongues start retreating with rates up to 20 m per year. Time series analysis based on high resolution satellite images and field observations were carried out for a better quantification of this rapid glacier decay. Thus the retreat of the glaciers from their Neoglacial maxima provides insights into the glacial geological processes and the remarkable recent climatic change.

The „Glacier Elevation Index“, as a proper approximation of the Equilibrium Line Altitude, was calculated for each glacier resulting in an average altitude of 5300 m for Lunana. This strongly depressed value compared to the Western Himalaya (e.g. Mount Everest region 5550 m) may reveal the more humid climatic conditions in northwest Bhutan. The occurrence of a probably active rock glacier marks the lower limit of recent permafrost at 4700 m a.s.l.

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Palaeoecological, amphibianfaunal comparisons between the localities Richardhof and Götzendorf/Miocene of the Vienna Basin

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Richardhof and Götzendorf/Sandberg, Upper Miocene localities of the Southern Vienna Basin, Lower Austria,

both belong to the Neogene Mammal Zone MN 9. While Götzendorf/Sandberg can precisely be classified into the

“Zone” F of the Pannonian after PAPP (1948) by evertebrates and into the late MN 9/~10 Ma by mammals (DAXNER-HÖCK 1993; DAXNER-HÖCK 1996; BERNOR 1993; BERNOR et al. 1993), the exact stratigraphical position of the locality Richardhof within the MN 9 still has to be called in question. Very probably, the small mammal-fauna is a bit older than the one of Götzendorf/Sandberg (DAXNER-HÖCK pers. advice).

After private collectors (P. Ullrich; H. Schwengersbauer) have found molluscs and vertebrates in Götzendorf/Sandberg, systematical digs under the leading of F. Bachmayer and H. Zapfe followed between 1988 – 1990 in the course of the FWF-project: P-7525-GEO. In 1992, G. Daxner-Höck dug there for the last time. The dig in Richardhof financed by the Ehrmann-fond and under the leading of G. Daxner-Höck, took place in summer 2002 and is still not absolutely finished yet.

Sedimentologically, the lentiform (<20 cm thick), rust-coloured fossil horizon in Götzendorf/Sandberg is located on the base of 6-7 m thick, fine sand. It is enriched with molluscs. In Richardhof, the layer RH-A/2 underlieing the amphibian fauna of this presentation consists of 70 cm thick, massy grey marl and contains a lot of molluscs.

Palaeoecological, amphibian faunal comparisons show, that the probably older locality Richardhof represented a swampy beach of the Pannonian freshwater lake within the Vienna Basin. The slightly younger locality Götzendorf/Sandberg was not dominated by this freshwater lake but by the Danube's precursor which passed nearby during the late MN 9. The existence of an oxbow lake 1. order is indicated by the amphibian fauna of Götzendorf/Sandberg. These palaeoecological conclusions correspond to the ones based on the rest of the fauna and the sedimentology.

The amphibian fauna of Götzendorf/Sandberg (MIKLAS 2002) consists of 33% Caudata and 67% Anura. Relating to their relative frequency, the 4 species of Caudata are mixed up with the 3 species of Anura. *Latonia gigantea* (53%), a giant, fossil Discoglossid (Anura) is most frequent and followed by *Mioproteus caucasicus* (27%), a fossil olm (Caudata), *Rana cf. ridibunda* (12%), the Lake Frog (Anura), *Andrias scheuchzeri* (3%), the fossil giant salamander (Caudata), the fossil species *Pliobatrachus cf. langhae* (3%; Anura), *Chelotriton paradoxus* (2%) related to the living genus *Tylotriton* (Caudata) and *Triturus roehrsi* (1%) relating to the living Smooth Newt (Caudata). Based on actuopalaeontological comparisons, the larvae of *Andrias scheuchzeri* needed well flowing water enriched with oxygen. The living species *Rana cf. ridibunda* indicates the existence of meadows and mainly prefers oxbow lakes 1. order. The fossil olm *Mioproteus caucasicus* in general shows a preference for flowing rivers (beside others: DEHM 1961). Further, the highly diverse fish-fauna containing the tropical groups phytophagous/ detritophagous/ zoobenthophagous (BÖHME, 2000; BÖHME, in press) as well as the fluvial sands as matrix of the fossil horizon confirm the theory of the existence of an oxbow lake 1. order in the locality Götzendorf/Sandberg.

In Richardhof, the 20% of Caudata are not mixed up with the 80% of Anura but entirely less frequent. Relating to their relative frequency, *Latonia gigantea* (35%) is followed by *Rana* sp. (23%), the Real Frog, *Hyla cf. arborea* (12%), the Common Tree Frog, and *Pelobates* sp. (10%), a spadefoot, which altogether belong to the Anura. The Caudata are represented by *Albanerpeton inexpectatum* (8%), a questionable, fossil species, *Mioproteus caucasicus* (8%), the fossil olm and *Triturus* sp. (4%). In contrast to Götzendorf/Sandberg, the rheophil species *Mioproteus caucasicus* is extremely less frequent in Richardhof. *Hyla cf. arborea*, the Common Tree Frog, lives climbing on trees these days, and *Pelobates* likes burrowing itself into the smooth, sandy sediments of beaches. The fish of Richardhof are very rare and they seem to be the result of predation. Taking this amphibian fauna and the grey marl as sediment of the fossil layer into consideration, the palaeoecological interpretation has resulted in a swampy beach with flood plains and woods as back country.

Although both Richardhof and Götzendorf/Sandberg belong to the MN 9, the palaeoecological comparisons are no direct ones. The aquatical, environmental situation within the Vienna Basin changed fundamentally during the Miocene. At the time of the Richardhof-fauna, the existence of amphibians in Götzendorf/Sandberg most probably had still not been possible. When the Danube's precursor had emerged in the late MN 9, it offered a living space to the amphibians.

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Using Sulphur-34 Analyses in Applied Hydrogeology. Examples from the Northern Calcareous Alps, Austria

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Within the structurally and hydrogeologically complex Northern Calcareous Alps, Austria, sulphate-bearing Permian-Triassic evaporite deposits of the Alpine Haselgebirge, Reichenhall and Raibl Formations are common and characterised by distinct $\delta^{34}\text{S}$ values of $\sim+11\%$, $\sim+25\%$, and $\sim+16\%$ VCDT, respectively (Spötl, 1988; Spötl & Pak, 1996; Göttinger et al., 2001).

Being largely unaffected by low-temperature dissolution processes, these sulphur stable isotopic signatures are inherited into the sulphate found in the groundwaters interacting with these highly soluble rocks thus providing a unique tool to trace the sulphate source(s) of the subsurface waters.

Table 1 shows some of the $\delta^{34}\text{S}$ values obtained from sulphate-bearing groundwater during projects carried out in the regions of Brixlegg and Innsbruck, Tyrol, Austria.

Sampling Site	Region	$\delta^{34}\text{S}$ (‰ VCDT)	SO ₄ (mg/l)	Sulphate Source
WS1	Innsbruck	+24,0	420	Reichenhall Fm.
MBL	Innsbruck	+21,6	230	Mainly Reichenhall Fm.
VEQ	Innsbruck	+12,8	26	Raibl Fm.
AQV	Brixlegg	+23,3	860	Reichenhall Fm.
GB1 - 4	Brixlegg	+16,8 – +21,3	130 - 330	Mixed
AHBM	Brixlegg	+15,3	660	Raibl Fm.

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For the Innsbruck project, which included estimating the extent and geology of the aquifer of large natural springs (flow-rate 150 l/s), $\delta^{34}\text{S}$ analyses helped along with hydrochemistry, $\delta^{18}\text{O}$ and ^3H analyses, in verifying the source of the sulphate rich waters. In this study, $\delta^{34}\text{S}$ analyses of the groundwater confirmed the existence of the Reichenhall Fm. in the subsurface of the catchment area, were as geological mapping only suggests the presence of Raibl Fm.

In Brixlegg, where a railway tunnel was constructed close to and penetrating various important mineral water (spa) aquifers, $\delta^{34}\text{S}$ analyses aided in confirming the extent and nature of these aquifers.

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