

Recent riverine input of pollutants into Lake Harkort (Northrhine-Westphalia, Germany) studied by geochemical analysis of surface sediments

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As a consequence of heavy industrialization since the 19th century, several main rivers within Northrhine-Westphalia became strongly polluted by industrial and urban sewage output and other sources. One of these rivers, the Ruhr, runs through the industrial area of the "Ruhr-region" from east to west and intersects several local industry centers. Over the last decades the economic structure of this region changed severely, with diminishing heavy industry and coal mining. This change in utilisation, the progress in cleaner production techniques and the greater environmental awareness within the population led to an improvement of river water quality. The water quality of the River Ruhr also improved over time, but this river as well as its tributaries in places are still polluted, as documented in continuously published water quality reports.

Along the River Ruhr, several flow-through lakes and reservoirs exist which are utilised for recreational purposes and water management. These lakes act as sediment catchment areas and provide excellent archives to study the long-term, i.e. month to several years, averaged pollution load of the rivers.

The recent input of pollutants into Lake Harkort, a Ruhr-reservoir near the city of Hagen, was determined based on surficial sediment analysis including those of the major tributaries of the catchment area. Geochemical and sedimentological analysis was performed on two grain size classes for 24 sediments, including determination of total amounts of carbon and sulphur, organically bound carbon, and magnetic susceptibility. Following organic solvent extraction by ASE and liquid chromatography separation (two-step MPLC) detection of selected pollutant classes like PCBs and PAHs was achieved by GC/MS.

Distribution patterns and origin of the pollutants from Lake Harkort and its tributaries will be discussed.

New sedimentological aspects of the glaciogenic Al-Khlata-Fomation (Permo-Carboniferous) on the southwestern flank of the Huqf axis (Oman)

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On the southeastern Arabian Peninsula (in the Sultanate of Oman) the permocarboniferous Gondwana Glaciation resulted in the deposition of the extremely heterogenous siliciclastic Al-Khlata-Formation (e.g. BRAAKMAN et al. 1982). The glaciogenic formation is of great importance for Oman's petroleum industry since its sandy parts host major oil reservoirs. Particularly in southern Oman many oilfields are producing hydrocarbons from these Al-Khlata reservoirs. The main problem in exploration and production arises from the very sudden lateral and vertical changes of lithofacies. Therefore geological investigations have been carried out recently in a study area on the southwestern flank of the Huqf axis where the best outcrops of the Al-Khlata-Formation are found. Here the formation's thickness of only 70 m (up to 750 m in the adjoining basin (BRAAKMAN et al. 1988)) is due to condensed sedimentation on the Huqf axis.



Fig. 1: The lowermost tillite of the Al-Khlata-Formation (bright rock at back, height of wall 5m) directly overlies intensively striated dolomites of the sedimentary basement (Precambrian). View towards the NE (= ice flow direction). Striation pavement, Wadi Al Khlata South, Oman.

The geological investigations encompassed extensive field work as well as a series of sedimentological methods such as thin section microscopy, SEM, X-ray diffractometry and grain size analysis. The following new aspects concerning sedimentology and depositional environment of the Al-Khlata-Formation have been derived:

Geological surface mapping and columnar profiling are summarized in a type section showing three distinct layers of tillite. These indicate that the permocarboniferous ice sheet prograded over the study area for at least three times. Statistical clast counts in different lithostratigraphic units clearly reveal a changing spectrum of the clastic material over the time.

The percentage of igneous and metamorphic clasts increases towards the younger tillites, revealing a progressing glacial abrasion deeper and deeper into the crust in the derivational area.

The following sedimentological parameters of the Al-Khlata-Formation have been confirmed: An intensively striated basement (see Fig. 1) and the occurrence of tillites containing blocks up to several meters in diameter prove the glaciogenic origin of the formation. Statistical strike-and-dip measurements of cross-bedding and glacial striations give evidence for a NNE to NE oriented palaeogradient. This fact clearly contradicts the theory of AL-BELUSHI et al. (1996) who claimed the ice flow to be SW oriented.

AL-BELUSHI, J.D., GLENNIE, K.W. & WILLIAMS, B.P.J. (1996): Permo-Carboniferous Glaciogenic Al Khalata Formation, Oman: A New Hypothesis for Origin of its Glaciation. - *GeoArabia*, 3: 389-404, Bahrain.

BRAAKMAN, J.H., LEVELL, B.K., MARTIN, J.H., POTTER, T.L. & VAN VLIET, A. (1982): Late Palaeozoic Gondwana glaciation in Oman. - *Nature*, 299: 48-50, London.

BRAAKMAN, J.H., LEVELL, B.K. & RUTTEN, K.W. (1988): Oil-Bearing Sediments of Gondwana Glaciation in Oman. - *AAPG Bulletin*, 72: 775-796, Tulsa.

Palaeocurrent analysis on the glaciogenic Al-Khlata-Fomation (Permo-Carboniferous) on the southwestern flank of the Huqf axis (Oman)

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The very heterogeneous Al-Khlata-Formation was deposited during the permocarboniferous Gondwana Glaciation in the southern

part of the Arabian Peninsula (BRAAKMAN et al. 1982). The glaciogenic formation consists of a sequence of glacially generated shales, siltstones, sandstones, conglomerates and tillites with numerous vertical and rapid lateral facies changes. The formation is one of the key oil-bearing reservoirs in south Oman accounting for 18% of south Oman's total Stock Tank Oil Initially In Place (STOIP). Lateral facies relationships are complicated by syndepositional salt withdrawal and dissolution, pronounced palaeotopography on the basal unconformity and intraformational unconformities, causing difficulties in accurate lateral and vertical prediction of both reservoirs and seals (SCHÖNICKE 1999).

Geological and sedimentological investigations have recently been carried out in a study area on the southwestern flank of the Huqf axis where the best outcrops of the Al-Khlata-Formation are found. Here the formation's thickness of only 70 m (WITTE 1999) - compared with up to 750 m in the adjoining basin (BRAAKMAN et al. 1988) - is due to condensed sedimentation on the Huqf axis. The field investigations encompassed statistical strike-and-dip measurements of cross-bedding and glacial striations giving evidence for a NNE to NE oriented palaeogradient. Palaeocurrent markers were measured in three litho- stratigraphic levels: A total of 400 glacial striae (on the top of the sedimentary basement), 111 cross beds in silty sandstones (glaciofluvial) and 184 cross beds in conglomeratic sandstones (high energy glaciofluvial) have been measured (Fig. 1).

The northeasterly to northerly oriented palaeocurrents correlate very well with the palaeoflow patterns of permocarboniferous Gondwana. Moreover the results clearly contradict the theory of AL-BELUSHI et al. (1996) who claimed that the Gondwana Glaciation originated from a mountainous glaciation due to crustal uplift with SW-oriented palaeoflows.

AL-BELUSHI, J.D., GLENNIE, K.W. & WILLIAMS, B.P.J. (1996): Permo-Carboniferous Glaciogenic Al Khlata Formation, Oman: A New Hypothesis for Origin of its Glaciation. - *GeoArabia*, **3**: 389-404,*, Bahrain.

BRAAKMAN, J.H., LEVILL, B.K., MARTIN, J.H., PORTER, T.L. & VAN VLIET, A. (1982): Late Palaeozoic Gondwana glaciation in Oman. - *Nature*, **299**: 48-50, London.

BRAAKMAN, J.H., LEVILL, B.K. & RUTTEN, K.W. (1988): Oil-Bearing Sediments of Gondwana Glaciation in Oman. - *AAPG Bulletin*, **72**: 775-796, Tulsa.

SCHÖNICKE, O. (1999): Facies Interpretation from Openhole Logs, Cores and Outcrops: Example of the Permo-Carboniferous Glaciogenic Al Khlata Formation, Oman. - Doctoral thesis, 1-190, 11 encl., TU Clausthal.

WITTE, J. (1999): Die Sedimentologie (Fazies, Transportrichtung, Material-herkunft) und Lithologie der glazigenen Al-Khlata-Formation (Permokarbon) im Rahmen der geologischen Entwicklung der südöstlichen Arabischen Halbinsel. - Master thesis, 1-228, 8 encl., TU Clausthal.

Diagenesis and fluid evolution of the NE-German Basin

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The NE-German Basin (NEGB) is part of the ESE-WNW striking, cratonic Southern Permian Basin of Central Europe. Its evolution commenced in the Late Carboniferous with the deposition of the Permo-Carboniferous volcanics. Thick sediments were accumulated during the subsequent phase of subsidence in the Permo-Triassic. The present day structural setup of the basin is characterized by halokinetic movement of the Zechstein evaporites and ESE-WNW striking features along the northern and southern margin related to Late Cretaceous inversion tectonics.

The reconstruction of the thermal and chemical evolution of palaeofluid systems in the NEGB was approached through petrographic, microthermometric and stable isotope analysis of samples from drillcores in the vicinity of the BASIN 9601 DEKORP-traverse. The use of optical cathodoluminescence allowed the further differentiation of mineral phases and identification of mineral growth patterns.

The focus of the investigations was set on the diagenetically formed mineral assemblages. A distinction was made between early (calcite, dolomite, anhydrite, quartz and late (quartz, calcite, illite, chlorite etc.) diagenetic cementing minerals. Joints and fractures, formed during the late Triassic subsidence, are filled with calcite, anhydrite and quartz. They are characterized by fluid inclusion salinities of 15-30 NaCl equiv. wt.% and mineral forming temperatures of up to 220 °C. The peak of the progressive basin subsidence during the Jurassic is characterized by fluid inclusions with salinities of 5-25 NaCl equiv. wt. % and maximum temperatures of 390 °C in the Rotliegend volcanics of the central basin (BRECHT & WOLFGRAMM 1998). A younger fluid system, apparently related to reactivation during the Cretaceous inversion, resulted in the formation of baryte, fluorite, anhydrite and quartz. This fluid system is characterized by an abundance of CH₄- and N₂-containing inclusions as well as distinctly lower temperatures of melting and homogenization of the aqueous inclusions. The further characterization of the electrolyte composition of the aqueous phases in fluid inclusions was achieved by Cryo-SEM-EDS analyses (WOLFGRAMM & SCHMIDT MUMM 2000). This showed that the early (Triassic) diagenetic fluid system is marked by NaCl-dominated compositions with only minor CaCl₂ and MgCl₂ con-

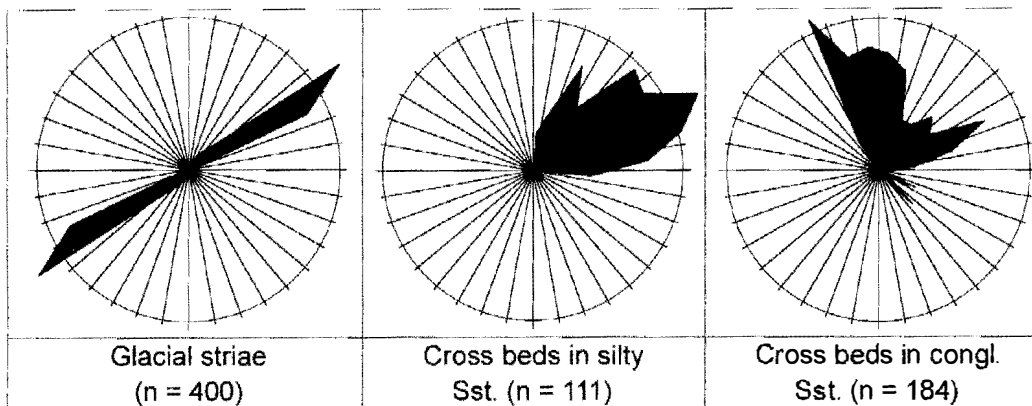


Fig. 1: The stereonets show the statistical evaluation of the palaeoflow measurements indicating that the palaeogradient was oriented towards northeasterly and northerly directions.