

lower Carboniferous Hochwipfel flysch. It is covered by an upper Carboniferous to Triassic post-Variscan sequence.

A first deformation event (D1) of probably lower Carboniferous age (Viséan-Namurian) has affected only the Eder nappe. Banded limestones and phyllites show a strong E-W-oriented stretching lineation (str1) of calcite and quartz, feldspars are deformed cataclastically. Strong isoclinal folds show axes parallel to str1. Tectonic transport was towards E indicated by scand ecc-fabrics, rotated clasts, and preferred orientations of quartz and calcite c-axes. Extensional kink bands perpendicular to str1 formed in a late stage of D1 under retrograde metamorphic conditions. The illite crystallinity method has been used on $<2\mu$ - fractions of all units to determine the metamorphic conditions (fig. 1). The limits for the diagenesis-anchizone boundary is $0.42 \Delta^{\circ}2\Theta$ and for the anchizone-epizone boundary $0.25 \Delta^{\circ}2\Theta$, as used by M. Frey at the University of Basel, Switzerland. Illite crystallinity data of three phyllites of the Eder nappe (unit 1 in fig.1) range between 0.20 and 0.21 $\Delta^{\circ}2\Theta$ for air-dried specimens and indicate lower epizonal conditions for D1.

Contemporaneously to D1 in the Eder nappe, the lower Carboniferous Hochwipfel flysch was deposited in a deepening trench to the south and olistolites of different sizes broke off the continental margin and slid into this trench. Both flysch and olistolites were deformed and metamorphosed during a second deformation event (D2) of probably lower Westfalian age (Hochwipfel nappe). A stretching lineation has not been developed. Axes of isoclinal folds are oriented approximately WNW-ESE. Thrusting has been towards S to SSW onto the southern foreland, that is in a broad sense northern Africa. Illite crystallinity data of the Hochwipfel flysch (unit 2 in fig. 1) range from 0.24 to 0.31 $\Delta^{\circ}2\Theta$ for air-dried specimens and indicate mainly upper anchizone conditions. Lower values at or above the anchizone-epizone boundary are probably due to tectonic influence.

Upper Carboniferous and Permian cover rocks have slightly higher illite crystallinity values (units 3 and 4 in fig.1) of 0.45 to 0.30 $\Delta^{\circ}2\Theta$ for air-dried specimens indicating mainly lower to medium anchizone conditions. With the exception of sample TC 22 of unit 4, glycolation of some samples show only a slight shift towards lower values.

ON THE ORIGIN OF MIGMATITES IN THE CENTRAL DAMARA OROGEN, NAMIBIA. MEGASCOPIC AND MICROSCOPIC EVIDENCES

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The Damara Orogen represents a part of the Pan-African mobile belt system which was formed at the triple junction of the Kalahari-Congo craton in Africa and the Sao Francisco cration in Brasil during late Precambrian to early Paleozoic time (e.g. Porada, 1989). During this orogenic event the central zone of the Damara Orogen underwent polyphase folding during three regional deformation phases. Intrusions of a series of voluminous pre-, syn- and posttectonic granitoids took place between 550 and 460 Ma. In the central zone, an increase in metamorphic grade from east to west has been established, indicated by a sequence of isograd reactions: It is important to note, that all isograds cut the tectonic structures discordantly, emphasizing that regional metamorphism in general outlasted the main deformation phases. Progressive metamorphism culminated in a migmatite area located in the western part of the central zone.

Previous petrographic and experimental work by Winkler (1983) and Hoffmann (1976) on rock samples from the central Damara Orogen dealing on granite and migmatite formation, showed that in the most parts the investigated leucosomes represent cotectic or close cotectic composition. Therefore they postulated minimum melting conditions for an in situ anatexis of high grade metapelitic schists in a water rich system.

The reconstruction of the fluid evolution during progressive metamorphism by Hoernes & Haffer (1985) indicated however, that fluid present conditions were only periodically verified among these rocks and they were confident that apart from these short periods of water expulsion, metamorphism occurred at \pm water absent conditions. Recent work of Masberg et al. (1992) showed that the Pan-African regional metamorphism culminated in the highest metamorphic part of the central Damara Orogen at conditions of dry low-pressure granulite facies (5kbar, 720 °C). Based on these observations doubts arised that the overwhelming part of migmatites could be products of in situ

anatetic partial melting in metapelites. During this study a reinvestigation of the migmatite area along a 100km traverse from Rooibank to Hentjesbaai parallel to the west coast of Namibia was carried out. In this area new outcrops due to blasting work during the build up of a water pipeline allowed detailed investigations of the mineralogy, the petrofabrics, the geochemistry and the isotope-geochemistry on relatively fresh material. Here we only report the results of the megascopic and microscopic investigations.

The highest concentration of migmatites are found in the Al-rich and quartz-rich metapelites, the latter ones are more abundant in the studied area. In general one can divide the investigated leucosomes in two major groups. They range from small coarse-grained leucocratic segregations in lenses and nodules concordant to the surrounding schistosity, within fold hinges and boudin necks on the one hand and veins and bigger accumulations up to several meters on the other hand. Such coarse-grained segregations in pelitic schists might reflect original layering or magma or aqueous fluids injected from another source region. They might as well reflect material derived from the neighbouring matrix during metamorphic differentiation and pressure solution or they can represent products of in situ partial melting due to high grade metamorphism or due to heat transfer from a magmatic body during an extensive contact metamorphism. All combinations of the above are possible.

Vein-like structures

The studied veins range in thickness from a few millimeters to tens of centimeters. Most of the leucosomes are medium to coarse grained and sometimes they show pegmatitic or aplitic character. Their modal composition range from granitic, granodioritic to tonalitic. Tonalitic leucosomes are more medium grained and the thickness of these layers range from few millimeters up to a few centimeters. Most of the leucosomes show sharp contacts to the surrounding country rocks and are in general concordant to the foliation of the host rock. Diffuse contacts are very rare, just so biotite selvages do not occur or only in a very small extent up to one millimeter. The fieldwork on the migmatites and related rocks shows that the major part of the vein like leucosomes are strongly foliated showing several kinds of folds. Most of them are complex isoclinal folded and refolded and are characterized by thickened crests and thinned limbs. Only a few intrusive veins show crosscutting relations to the former ones. These veins are undeformed and postdate F3 fold phases and belong therefore to posttectonically intruded granitoids and pegmatites. No irregular fold characteristics like convolute folds in the migmatites can be observed which may result from folding of a rock containing melt. The tectonic and metamorphic history as well as the close spatial relationship of the migmatites to the surrounding orthogneisses and the metapegmatites leads to suggest that the formation of the overwhelming part of the leucosomes belongs to melt injection due to several magmatic events in an early stage of regional deformation and metamorphism and in relation with the voluminous syntectonic intrusion of granitoids. The veins are emplaced into a deforming metamorphic succession. Thus solid state deformation during or after emplacement took place. The lit-par-lit character of most of the vein-like leucosomes is also documented by the presence of minerals which are unrelated to the surrounding country rocks implying their transport from deeper levels into the now exposed crust on the premises that the inclusion had remained coherent during melting and intrusion.

Among these magmatic leucosomes there are also vein-like ones which were formed by subsolidus processes. Such quartz- or quartz-albite- veins form in metapelites and metapsammites parallel to and only during the formation of the first slaty cleavage (s1a). At higher metamorphic temperature these veins can be mineralized by biotite, feldspars, garnet etc. If the concentration of the minerals above, especially feldspar becomes more abundant with increasing metamorphic grade the veins can show megascopically typical granitic or even pegmatitic appearance. Due to microfabric features there is strong evidence that these veins have been formed by metamorphic differentiation of aluminous pelitic schists. In addition, these mineralized quartz veins exhibit different geochemical patterns to the lit-par-lit veins and the leucosomes produced by sedimentary layering and are therefore strongly related to the process of metamorphic differentiation.

Flecky structures

The second type of more or less coarse-grained leucocratic segregations can be observed especially in fine to medium grained biotite-schists, containing porphyroblasts of garnet, cordierite, plagioclase and alkali-feldspar. Occasionally one can find such flecky structures also in orthogneisses. These corona-like structures consist of a core and a haloe. In contrast to the host rock the haloes show an impoverishment in biotite and a relative enrichment in quartz, plagioclase and/or alkalifeldspar. The core of these leucocratic segregations may be either clusters of garnet crystals or a large single garnet

porphyroblast. Field observations suggest that the flecky gneisses are products of regional metamorphism and deformation because the leucocratic parts are similar deformed as the host rock. None of them show evidences of partial melting but all of them show granoblastic polygonal textures which could be used as evidence of plastic deformation. Thus the flecky gneisses of the studied area are not products of a dehydration melting of biotite but were formed by a diffusion controlled metamorphic segregation process prior to peak of metamorphism.

References

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TERRANE ASSEMBLY IN THE VARISCAN BELT OF EUROPE

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The distribution of the major continents in the Early Palaeozoic can be recognised by endemic faunas, by faunas and facies characteristic of latitude, and by palaeomagnetic data; all three lines of evidence can now be reconciled.

In the Cambrian, different parts of Europe were parts of different continents:

Baltica: Europe north of the Transeuropean suture was in low latitudes.

Avalonia: including England and the Ardennes, and both margins of the Rhenohercynian, was also at low latitudes, but on the edge of Gondwana; in the Ordovician, Avalonia separated from Gondwana (forming the Rheic Ocean) and was fused to Baltica by the Early Silurian.

Gondwana: like pre-Ordovician Avalonia, central and southern Europe were also attached to Gondwana (both were on the Cadomian arc), but unlike Avalonia, southern Europe was in low latitudes in the Cambrian and remained attached to Gondwana throughout most of the Palaeozoic.

The microcontinent of Avalonia was first distinguished (Cocks & Fortey 1982) by the fact that it had low-latitude faunas like parts of Gondwana in the Early Ordovician, but that subsequently these were gradually replaced by Baltic species, so that by the Late Ordovician Avalonia and Baltica had almost identical trilobites and brachiopods.

We now have palaeomagnetic data showing that, while both Avalonia and Baltica moved north to low latitudes during the Ordovician, they also converged before the Silurian. Ostracodes, which have no pelagic larval stages, remain distinct between Avalonia and Baltica until the Early Silurian. The northern ostracodes do not cross to the Bohemian and the Armorican parts of Gondwana until the Emsian, when the Rheic Ocean finally closed.

The last phase of the Caledonian Orogeny in England is now known to be Emsian: the same age as the Acadian Orogeny in eastern Canada. Early Devonian (preEmsian) freshwater fish are identical north and south of the Rhenohercynian (they occur in south Devon and the southern Taunus), so it was after this compressional event that the Rhenohercynian basin opened.

The precise lines of the Transeuropean and Rheic sutures are still uncertain. They can best be determined by noting pre-Silurian faunal distinctions across the former and pre-Acadian distinctions across the latter.