sources, but can also provide hints about nitrogen transformation processes such as nitrification and denitrification in the unsaturated zone.

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Geology, stable isotope and fluid inclusion studies of the serpentinised Kenticha ophiolites, south eastern Ethiopia

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The Adola granite-greenstone terrane covers an area of approximately 5000 km^2 in southern Ethiopia. It is characterised by two linear, closely spaced, N-S trending belts of metamorphosed supracrustal rocks, namely the Megado volcanosedimentary belt in the west and Kenticha ultramafic belt in the east. The former consists of ultramafic and tholeiitic basic volcanics and intrusives which are intercalated with sediments made up predominantly of arkoses, feldspathic quartzites, quartzites and pelites together with subordinate polymictic conglomerates and graywackes. In contrast, the Kenticha belt is dominated by ultramafic rocks, with subordinate amphibolites, biotite schists, minor graphitic schists and marbles (Gilboy 1970; Chater 1971, Billay et al., 1997). The two volcanosedimentary belts are surrounded and separated by a gneissic terrane which comprises para- and orthogneisses with subordinate muscovite-quartz schists, staurolite-garnet-biotite schists, impure marbles and amphibolites.

The Kenticha belt has been affected by amphibolite-facies metamorphism of the staurolite-almandine and kyanite-almandine-muscovite subfacies. The ultramafic rocks generally trend north-south (7-8 km long and up to 1 km wide) and occur as hill- and ridge-forming bodies extending for about 30 km. They occupy higher structural levels in the granite – greenstone succession. The Kenticha serpentinite is composed of more than 70 vol.% serpentine, olivine, pyroxene, and opaque (chromite and magnetite). Mesh texture of chrysotile is common with minor antigorite. Olivine and pyroxene relicts imply a peridotitic protolith. Based on field relations, geochemical data and PGE over chondrite normalised plots, the Kenticha ultramafic rocks are considered to be ophiolites. Associated with these ophiolites are also complex pegmatites containing amazonites, columbo-tantalite among others. Within the granite-pegmatite system late-magmatic alterations (albitization, sericitization, kaolinization) and development of amazonite and microcline are widely developed.

The Kenticha ultramafic rocks are completely serpentinised and the nature of the fluid involved in the serpentinisation process is not known. When fluids interact with ultramafic rocks serpentine-group minerals and subordinate chlorite, talc, tremolite, brucite, magnesite and magnetite form. The temperatures, isotopic composition of the fluids and water/rock ratios during serpentinisation are recorded in the oxygen and hydrogen isotopic composition of the alteration products (e.g. Barnes and O´Neil, 1969; Wener and Taylor, 1973; 1974; Gregory and Taylor, 1981; Kyser et al., 1999).

Fluid inclusions in calcite within the serpentinised ultramafics are relatively small (7-15 μm), rounded to irregular and occur in intergranular cluster and intragranular trails. Many of them are monophase at room temperature which is attributed to the metastable absence of the vapour bubble. The fraction of the liquid phase, when the inclusions contain a vapour and a liquid, is constant around 0.9. On reheating after cooling below -80°C, first melting is observed from -52° to 44°C, which may indicate either eutectic melting in the binary H_2O-$CaCl_2$ or the ternary H_2O-NaCl-$CaCl_2$ system. Since melting of hydrohalite could not be observed we calculated inclusion properties assuming the binary H_2O-$CaCl_2$ system. Ice melting was observed between -30 and -20°C from which salinities between 24 and 20 wt% salt can be derived. The inclusions presumably trapped a homogeneous fluid, indicated by the uniform fraction of the liquid phase. Homogenization temperatures ranging from 100 to 140°C are regarded as minimum temperatures for the calcite host formation.

Stable isotopic composition from the kenticha ophiolite have been measured in order to define the nature of serpentinisation processes occurring in this region.

Stable isotope compositions have been determined from serpentines of a 50 meter deep borehole of the Kenticha ophiolite (drill-core 5/5).

∂D, ∂^{18}O values (-99 to –85 and 5.3 to 10.1, respectively) and mineralogy indicate that serpentinisation took place on continent at relatively low temperature in the presence of hydrothermal-meteoric fluids (Fig. 1). Two samples of chrysotile-lizardite have ∂^{18}O of 14.1 and 12.3 suggesting high water/rock ratios and low formation temperature. These two samples most probably come from depth levels situated near faults. The measured ∂D values of whole rock indicate that there is a correlation between the ∂D of the serpentine and that of local meteoric water, regardless of the age of the serpentinisation.

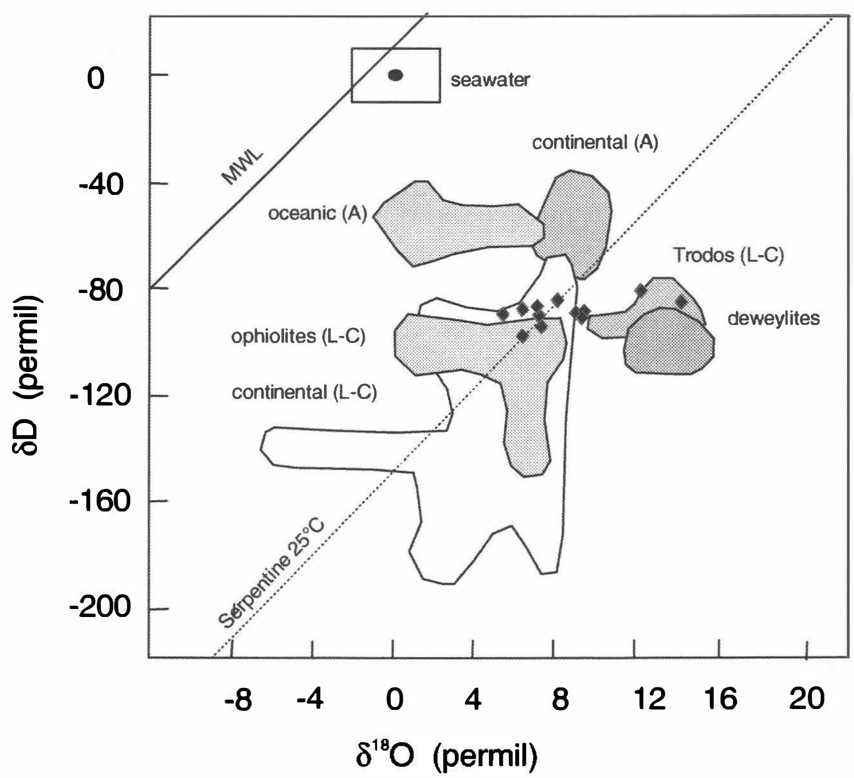

Fig 1: ∂D vs. $\partial^{18}O$ plot showing the isotopic composition of Kenticha serpentinites, and the fields for oceanic and continental lizardite and crysotile, continental antigorite, deweylites and Trodos serpentinites (after Wenner and Taylor, 1973, 1974, Kyser, 1999).

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The Austrian Network for Isotopes in Precipitation (ANIP)

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The Austrian Network for Isotopes in Precipitation (ANIP) started in 1972. At some stations samples have already been taken since the 1960s. 71 stations ranging from 120 to 2250 m in altitude are presently in operation all over Austria with some preference given to the Karst areas north and south of the Alpine mountain range (Fig. 1). The precipitation water is collected on a daily basis in ombrometers (500 cm^2) and mixed to monthly samples. All samples not measured immediately have been stored in 1L bottles in a specially dedicated cellar (16000 samples) in Vienna and are available for analysis in the future. The aim of ANIP is to provide input data for hydrological and hydrogeological investigations and a data-base for climatological research.