Geochemical characteristics of cold seep carbonates as records of gas venting in Shenhu area, northern South China Sea

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Methane-derived carbonate precipitation, as an important indicator of gas venting, occurs at cold seeps in active and passive continental margins worldwide. Cold seep carbonates, which have relationship with gas hydrate dissociation and/or compaction of rapidly accumulating sediments, can supply information about fluid sources, fluid discharge, migration paths over geologic time.

In this study, we report geochemical characteristics of authigenic carbonate chimneys from Shenhu area of the northern continental slope of South China Sea, where gas hydrates were firstly drilled in 2007. The chimneys are mainly composed of aragonite, calcite and ankerite. Carbon and oxygen isotopic compositions are similar to those of seep carbonates reported from the nothern South China Sea and elsewhere. The strongly negative $\delta^{13}C$ values (-47.65 to -29.67‰ VPDB) indicate biogenic methane-derived as a major carbon source. Another distinct feature is slight enrichment of $\delta^{18}O$ (2.43 to 4.09‰ VPDB) which is implied precipitation from ^{18}O–rich fluids. Furthermore, C-O isotopic compositions of a chimney cross-transect suggest an internal pattern controlled by varing seepage rates, as evidence of alternating fluid characteristics and precipitation conditions during the formation of chimneys. PAAS-normalized REE patterns display positive Ce anomalies with low ∑REE values (average 12.6 ppm), suggesting an oxygen-deficient depositional environment. $^{87}Sr/^{86}Sr$ ratios (0.709171 to 0.709235) of cold seep carbonates are indistinguishable from modern seawater (mean 0.709175), reflecting a shallow, marine Sr source.

Geochemical characteristics indicate that the carbonates are products of anaerobic oxidation of methan (AOM) mediated by microbes. The source of ^{18}O–rich fluids possibly includes the dissociation of gas hydrates present at depths in the area.

Origin of zircon in garnet peridotites: a study of U-Pb SHRIMP dating, mineral inclusions and REE geochemistry

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Garnet peridotites (GP) provide insight into geochemical processes within the upper mantle, which can be recorded by zircon. We dated by SHRIMP, determined the trace and REE and investigated the inclusions of zircon from GP of: (a) the Erzgebirge, Bohemian Massif and (b) Alpe Arami (C' Alps).

Zircons from the GP of Erzgebirge are distinguished into: (a) Inclusion-free with weak cathodoluminescence (CL), high HREE contents and a negative Eu anomaly. They have a $^{206}Pb/^{238}U$ age of 332.1±4.8 Ma (95% c.l.), younger than the ca 341 Ma age ascribed to the metamorphic peak by previous studies and similar to ca 332-330 Ma ages suggested for mid-crustal exhumation. (b) Inclusion-bearing, very U-rich zircons with no, or very weak CL, high trace- and REE contents, very rich in LREE and flat chondrite-normalised REE patterns. The inclusions are a few µm large and include quartz, albite, K-feldspar and felsic melt. Zircons of this type did not yield a reliable SHRIMP age because of their very high U contents. MREE-HREE partitioning between zircon of both types and garnet reveals that the two minerals were far from equilibrium. Our results show that zircon in the GP of Erzgebirge formed during exhumation, within the stability field of plagioclase by infiltration of two types of fluids/melts with different chemistry. These fluids/melts probably originated from the immediately adjacent felsic gneisses.

Metamorphic zircon domains from a retrograded GP at Alpe Arami contain enstatite, olivine, phlogopite, serpentine and tremolite inclusions in 33.4±0.5 Ma old bright CL domains formed by recrystallisation of CL-darker, 35.4±0.7 Ma old zircon domains. Above minerals occur also in the host rock. The 33.4±0.5 Ma age reflects an exhumaion stage in granulite-facies, including partial melting of the meta-granitic country rocks. The inclusion-bearing zircon domains are poor in LREE and show strong enrichment in HREE indicating supply by the HREE rich immediate fluid phase.

The two case studies of GP zircons examined here strongly demonstrate that external fluids, with respect to the GP, are responsible for the formation and/or recrystallisation of zircon in these rocks. The source of these fluids can be traced via zircon age, inclusions and REE geochemistry.