

Affinity of the Trans-North China Orogen: Constraints from detrital zircon U-Pb and Hf isotope compositions from the Fuping Complex, North China Craton

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There is a broad consensus that the North China Craton was assembled by the collision between the Eastern and Western Block along the Trans-North China Orogen at ~1.85 Ga [1]. However, controversy exists on the affinity of the Trans-North China Orogen. The Fuping Complex is located in the central segment of the Trans-North China Orogen and is considered to be the most promising area to investigate the evolution history of the North China Craton. In this study, we investigate the U-Pb and Hf isotopes of about 200 detrital zircon grains from the Wanzi Supracrustals, which are the major lithologies of the Fuping Complex, and the results provide important insights into the problem. The analytical results on metamorphic zircon rims give ages of 1825-1843 Ma, corresponding to the tectonothermal event that led to collision between the Eastern and Western Blocks. Other analytical data on igneous zircon cores mainly yield two age populations at ~2.1 and ~2.5 Ga, with some inherited ages scattering between 2.6 Ga and 2.8 Ga. These two groups of age are equivalent to those of the ~2.1 Ga Nanyang granitic gneiss and the ~2.5 Ga Fuping TTG gneiss, respectively [2]. All zircons with ~2.5 Ga age from different samples possess positive initial ϵ_{Hf} values, ranging from +1.4 ~ +10.9, with a peak at about +5. The depleted mantle Hf model ages of these zircons show a peak at about 2.8 Ga, identical to the main crustal formation age of the Eastern Block [3] and distinct from that of the Western Block [4]. These data suggested that the Fuping complex was emplaced in a continental margin arc system at the western margin of the Eastern Block, thus have affinity to the Eastern Block. The zircons of 2.1 Ga population have initial ϵ_{Hf} values of -4.9 ~ +6.0 and a younger depleted mantle Hf model age peak at 2.61-2.67 Ga, interpret as a remelting of the above 2.5 Ga rocks with minor juvenile material contribution. This study was supported by the Hong Kong RGC Grants (7048/03P, 7063/06P, 7058/04P and 7055/05P) and a NSFC grant (40429001).

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Geochemical characteristics and isotope dating of moyite at the southeastern margin of the Kuruktag block, Xinjiang, China

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The plutons from the southeastern margin of the Kuruktag block, Xinjiang, which belong to Proterozoic or Carboniferous according to previous studies, are mainly the moyites. Geochemically, these rocks are metaluminous, alkaline I-type granites. The rocks are also characterized by enrichment of LREE and the REE-Chorinite patterns are similar to those of the he crustal granite. With respect to the trace element, the spider diagrams of the rocks are consisted with the volcanic arc granites. The zircon U-Pb dating yielded an age of 430.6 ± 1.0 Ma (Fig 1), representing the emplacement age of these plutons. This study indicate that the existing of late Caledonia tectonic-magmas in the study area at the first time. The volcanic arc granites suggest the southeastern margin of Kuruktag block was a part of the east Tianshan early Paleozoic magmatism arc.

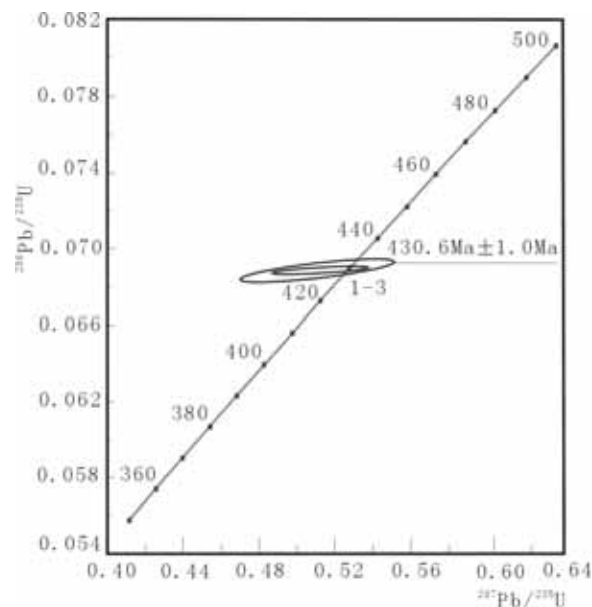


Figure 1. U-Pb dating result diagram of zircon from moyite

Keywords: Zircon U-Pb dating, moyite, the southeastern margin of the Kuruktag block

Li and B isotope characteristics of ultrahigh-pressure metamorphic rocks from Sulu, China

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We analyzed the Li and B isotopic composition of metamorphic rocks from Sulu recovered by the Chinese Continental Drilling Program to constrain the behavior of Li and B and their isotopes through dehydration of subducted crust up to conditions of ultrahigh-pressure (UHP) metamorphism and to rehydration during exhumation of UHP rocks. The analyzed samples show large variations in both Li content and $\delta^7\text{Li}$, ranging from 4 to 29 ppm and -12.4 to 0.5‰ for fresh eclogite, 8 to 22 ppm and -3.6 to +3.6‰ for retrogressed eclogite, and 1.2 to 11.6 ppm and 1 to 3.1‰ for ultramafic rocks, respectively. Most samples are characterised by very low B contents (<1ppm), with $\delta^{11}\text{B}$ values varying from -14 to 0‰ for fresh eclogite, -10 to -1‰ for retrogressed eclogite, and -3 to +12‰ for ultramafic rocks. The Li and B isotope data indicate that isotopically heavy continental basaltic rocks have been transformed during subduction into isotopically light eclogites. Fluids released from the subducted rocks may (i) induce local melting and eventually be “stored” in local melt pockets and veins within restitic rocks or (ii) metasomatize mantle rocks. In both cases, mobilization of Li and B through the fluids results in large heterogeneities in the concentrations of Li and B, $\delta^7\text{Li}$ and $\delta^{11}\text{B}$ on centimeter to decimeter scale. For instance, higher B content and heavier $\delta^{11}\text{B}$ value in garnet peridotite relative to neighboring eclogite (subducted crustal rocks) indicate that mantle-derived rocks were metasomatized by fluids released from the subducted slab. Similar small-scale isotopic heterogeneity is also found between fresh and amphibolized eclogite, illustrating the addition of isotopically heavier Li and B during retrogression. Because of the superposition of the effects of dehydration and retrogression and the mineralogical control on the partitioning and isotopic fractionation of Li and B, Li and B and their isotopes may or may not behave coherently in the same system during slab subduction and subsequent exhumation of UHP rocks.

Study on fluid inclusions of Cu-Au skarn deposits in the Tongling region, Anhui Province

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Introduction

The Tongling region is an important ore district of the Yangtze metallogenic belt in east China. Its representative of skarn deposits are world famous (e.g., Chang *et al.* 1991; Pan and Dong 1999; Yang and Lee, 2006). This study focus on the compositions and temperature of fluid inclusions of these Cu-Au deposits as well as their genesis.

Experiment and Results

The chemical compositions of fluid inclusions are determined with RM-1000 laser Raman spectroscopy produced by Renishaw Company, at the State Key Lab of Geol. Proc. & Mineral Res., China Univ. Geosci. Three types of fluid inclusions: daughter mineral, gas-rich and liquid inclusion have been identified. Compositions of fluid inclusions are mainly composed of H₂O, CO₂ and CH₄ with homogenization temperature from 106°C to 441 °C. Boiling is an important factor during Cu-Au mineralization provided by coexisting daughter minerals and gas-rich inclusions, indicating that the ore-forming fluids were experienced an evolution from high temperature to moderate one. Evidences from this study and the previous isotopes deduced that ore-forming fluids of Tongling Cu-Au deposits are magmatic in origin. Temperature at boiling state led to enrichment of large amounts of copper and gold during rock-fluid interaction.

Acknowledgments

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Geochemical characteristics of the Early-Cretaceous mafic rocks from eastern China

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Sr-Nd-Pb isotopic compositions of the Early Cretaceous mafic rocks from different tectonic units of the eastern China, including western Shandong province in North China, Dabie orogenic belt and northeast margin of the lower Yangtze region are studied to deduce the characteristics of the Early Cretaceous subcontinental lithospheric mantle (SCLM) of eastern China.

The results suggest that the sources of these mafic rocks from different units have significant different Sr-Nd-Pb characteristics. The mafic intrusions from Jinan and Zouping, west Shandong province, have lower initial Sr compositions of 0.7041 ~ 0.7055, $\epsilon_{Nd}(t) = -6 \sim -18.7$, and $^{206}Pb/^{204}Pb(t) = 16.55 \sim 17.00$, $^{207}Pb/^{204}Pb(t) = 15.22 \sim 15.35$, $^{208}Pb/^{204}Pb(t) = 36.29 \sim 36.95$. Those from North Dabie have $^{87}Sr/^{86}Sr(t) = 0.7067 \sim 0.7085$, $\epsilon_{Nd}(t) = -6.5 \sim -19.1$, $^{206}Pb/^{204}Pb(t) = 16.37 \sim 17.40$, $^{207}Pb/^{204}Pb(t) = 15.31 \sim 15.45$, $^{208}Pb/^{204}Pb(t) = 37.11 \sim 37.98$. Compared with the mafic rocks from North China craton, those from Dabie have higher μ data and Th/U ratios, much closer to EM I in the $^{206}Pb/^{204}Pb$ - $^{207}Pb/^{204}Pb$ diagram. However, the basaltic rocks from Luzhong, east Yangtze block have $^{87}Sr/^{86}Sr(t) = 0.7057 \sim 0.7065$, higher $\epsilon_{Nd}(t)$ data (-3.9 ~ -6.2), and also higher Pb isotopic ratios: $^{206}Pb/^{204}Pb(t) = 17.88 \sim 18.08$, $^{207}Pb/^{204}Pb(t) = 15.50 \sim 15.55$ and $^{208}Pb/^{204}Pb(t) = 37.93 \sim 38.18$, close to EM II. In $I_{Sr-\epsilon_{Nd}(t)}$ and Pb evolution diagrams, the samples from each unit are well coupled with the area of lower crust, respectively.

The enriched isotopic characteristics of the mafic rocks from all units suggest the contribution of the lower crustal materials into the mantle source. Based on geochemical, isotopic and geochronological data, crustal contamination during magma ascending can be eliminated. Thus, it can be concluded that the involvement of different lower crustal material is one of the main processes which resulted in different isotopic characteristics in the mantle sources of different tectonic units in Eastern China at the Late Mesozoic by source mixing. The lithosphere delamination may be a possible dynamic model for explaining the incorporation of the lower crustal materials into the mantle source, but metasomatism model cannot be ruled out.

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Why carbonatites in the Lesser Qinling have high HREE compositions?

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Carbonatites are typically characterized by very high concentrations of LREE. They have very high LREE/HREE ratios. However, the carbonatite dykes in the Lesser Qinling, China, shows flat to weakly LREE enriched chondrite-normalized patterns (La/Ybn=1.0-5.5), which is in marked contrast with all other published carbonatite data. The calcite crystals analyzed by LA-ICPMS also show similar geochemical feature to their whole rocks. Xu *et al.* (2006) suggested that the carbonatites represent calcite-rich cumulate that had crystallized from a carbonatite melt. However, it cannot explain that why they contain higher HREE (e.g. Yb>30 ppm) than all other published carbonatite data. Calcite-rich cumulate is common in carbonatites (Woolley and Church, 2005). But the process cannot produce that other carbonatites have high HREE. Xu *et al.* (2006) considered that strong enrichment of HREE in the carbonatites may require their derivation by small degree of melting from a garnet-poor source. The explanation is not ideal, because other carbonatites may also derive from a garnet-poor source, and do not show high HREE contents. In addition, these carbonatite dykes is rarely intergrowth with pegmatitic quartz vein. Field observation indicates that their ages are close. Thus the high HREE abundances in the carbonatites may indicate that they underwent complex genesis processes. Regrettably, we cannot get unambiguous answer.

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The age and reworking of Cathaysia crustal basement

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U-Pb dating and Hf isotope analysis of detrital zircons have been used to analyse the crustal evolution of the eastern and western parts of the Cathaysia Block in SE China. Zircons from the Oujiang River in eastern Cathaysia indicate that the basement is dominantly Paleoproterozoic (1850-1870 Ma, 2100-2400 Ma) in age with minor Archean components; it was extensively reworked in Jurassic-Cretaceous time (100-155 Ma) to produce the widespread Yanshanian magmatic suite. Both the 1850-1870 Ma event and the Yanshanian magmatism show wide ranges in Hf-isotope composition, consistent with mixing between crustal and juvenile magmas. Marked downstream changes in the relative proportions of zircon age populations emphasize the care required in using detrital zircon data to estimate continental growth rates. Zircons from the North River indicate that the crust of western Cathaysia was generated mainly during Neoproterozoic time, although it contains some Archean (2500-3500 Ma) to Mesoproterozoic components. This crust was strongly reworked during Caledonian (ca 450 Ma), Indosinian (ca 240 Ma) and Early Yanshanian (ca 160 Ma) thermal events; there is little evidence for juvenile crustal growth in any of these events. The distinct patterns of crustal evolution suggest that eastern and western Cathaysia may represent separate microcontinents, accreted to the older Yangtze craton, and transposed by extensive strike-slip faulting along major sutures.

Geochemistry of dissolved rare earth elements in the Xijiang River, China

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Flowing in the south of China, the Xijiang River is the largest tropical and subtropical rivers in Asia. It originates in the Maxiong Mountain on the Yunnan-Guizhou Plateau, drains a large area of typical karst landform especially in its upper-middle reaches in Yunnan, Guizhou and Guangxi Provinces, where is the center of the Southeast Asian Karst Region. This work focuses on the geochemical characteristics of dissolved rare earth elements (REEs) in the rivers draining the karst regions.

Concentrations of dissolved REEs of the mainstream and its tributaries were measured by using a method involving solvent extraction and back-extraction and subsequent measurements on ICP-MS. The rivers have very low dissolved REEs concentrations, range from 24 to 689 ppt, with a mean value of 125 ppt. The pH value, major cation and DOC (dissolved organic carbon) concentrations of the river waters are the most important factor controlling the concentrations of dissolved REEs in the river water. Negative corrections are observed between dissolved REEs concentrations and pH and major cation concentrations, and a positive correction is also observed between dissolved REE concentrations and DOC concentrations.

Most of river samples have heavy REE enriched patterns relative to PAAS (Post Archean Australian Shales), with $(La/Yb)_N=0.26-0.94$, mean value=0.68. The obvious negative correction are observed between $(La/Yb)_N$ ratios and pH value, HCO_3^- and DOC concentrations. Usually, fractionation of REEs occurs during weathering and transport processes. LREE (light rare earth element) were preferentially absorbed the particle, and HREE (heavy rare earth element) preferentially dissolved to solution from rock during weathering process. Moreover, The HREE forms stronger complexes than the LREE with inorganic ions, such as CO_3^{2-} and OH^- . So the enrichments in heavy REE for the Xijiang river waters, which drains a large area of karst landform, are most easily explained by the formation of carbonate and hydroxide complexation in solution. Most of river samples show negative Ce anomalies, and the most pronounced negative Ce anomalies occur in rivers of high pH. So the negative Ce anomaly is strongly pH-dependent in alkaline rivers.

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Dependence of the external and surface morphologies of matrix olivine particles on growth condition

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We have synthesized olivine particles from silicate vapor to study the growth mechanism of the matrix olivine in meteorites like Allende chondrite.

These matrix olivine particles in primitive meteorites were found to exhibit various morphologies and surface microtopographies [Nozawa *et al.*, 2007 this conference]. Since morphologies involve a lot of information about the growth conditions, we have experimentally tried to reproduce the morphologies and surface microtopographies to compare these morphologies with the natural one.

Forsterite melt droplets were prepared in a graphite cell (45×20×30 mm) in a vacuum chamber (Ar, 100 Pa). A 100W of CO₂ laser was employed to heat a forsterite polycrystalline spherule for melting in <100 sec. There is a temperature and gas concentration gradient along the graphite plate. The former and the latter were measured respectively by a thin ($\phi=0.1\text{mm}$) thermocouple and by measuring the thickness increase interferometry during the experiment. The forsterite crystals were characterized by TEM, FE-SEM, AFM and DICM. The latter two have been employed to observe the surface microtopographies.

As the temperature T , decreased and thus the supersaturation, σ of the vapor increased, the forsterite morphology changed from a bulky type ($T=1000\text{-}1450^\circ\text{C}$, $\delta < 9$) to a platy type ($T=700\text{-}1000^\circ\text{C}$, $\delta = 9\text{-}17$ (Fig.1)), then to a columnar needle shape ($T=500\text{-}820^\circ\text{C}$, $\delta = 13\text{-}25$), and finally to a droplet type ($T < 500^\circ\text{C}$, $\delta > 25$). Various 2-dimensional islands with the step height of 0.3 nm-few nm were observed: rectangular growth islands with a smooth-edge step ($T=1200\text{-}1500^\circ\text{C}$, $\delta < 2$), islands with a rough-edge step ($T=900\text{-}1200^\circ\text{C}$, $\delta = 3\text{-}10$), and a droplet type ($T < 800^\circ\text{C}$, $\delta > 16$). These external and surface morphologies have been compared with natural matrix olivines.

In conclusion, these external and surface morphologies are comparable to those of matrix olivine observed in the matrix of Allende meteorite. Therefore, these olivine are concluded to be formed at 2000°C followed by rapid cooling in ~10 s. down to 700°C.

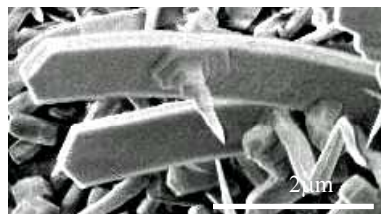


Fig.1.
Platy type
forsterite crystal
grown at
 $T=700^\circ\text{C}$, $\delta=9$.

Particle fluxes and scavenging of radionuclides in the western Northwest Pacific Ocean

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Introduction

²³⁰Th, ²¹⁰Pb and Pu are particle-reactive radionuclides and they are therefore removed from the water column by a scavenging process. Because of substantial input of terrigenous materials from riverine input and atmospheric input of continental dust, and the relatively high primary productivity, the western Northwest Pacific margins may be important for removal of reactive radionuclides by scavenging (Yamada and Aono, 2006). The objectives of this study are to measure the activities of ²¹⁰Pb, ²³⁰Th and ^{239,240}Pu in settling particles in the western Northwest Pacific margin and to discuss the removal of reactive radionuclides by scavenging and particle transport processes on the margins of the western Northwest Pacific Ocean.

Materials and methods

A mooring of three conical time-series sediment traps was deployed at two sites in the western Northwest Pacific Ocean for nine months. The analytical procedure for ²¹⁰Pb, ²³⁰Th and ^{239,240}Pu was essentially the same as that described by Anderson and Fleer (1982). A double-focusing sector-field ICP-MS instrument was used for the determination of the Th and Pu isotopes in settling particle samples (Zheng and Yamada, 2006).

Results and discussion

Total mass fluxes, ²¹⁰Pb fluxes, ²³⁰Th fluxes and ^{239,240}Pu fluxes showed large seasonal variations and their weighted mean fluxes tended to increase with depth, with an especially large increase near-bottom. The ratios of the observed ²¹⁰Pb fluxes to the ²¹⁰Pb deficiency fluxes in the near-bottom traps ranged between 1.22 and 2.63. The mean total ²³⁰Th fluxes at the near-bottom traps were 4.2–6.7 times higher than that expected from production in the overlying water column. The high fluxes of particulate ²¹⁰Pb, ²³⁰Th and ^{239,240}Pu collected by the near-bottom traps reflect a combination of enhanced scavenging of dissolved ²¹⁰Pb, ²³⁰Th and ^{239,240}Pu by the high fluxes of particles in the region, as well as the lateral redistribution of particulate matter itself by downslope gravitational settling and by alongshore transport by currents.

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Coupled C-S-Fe isotope variations in Archean-Paleoproterozoic shales trace microbial metabolisms and redox state in the early Earth

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Systematic variations among C_{org}, S, and Fe isotope and elemental compositions in 89 low-metamorphic grade drillcore samples of fine-grained Archean-Paleoproterozoic sedimentary rocks (Kaapvaal and Pilbara cratons) constrain microbial metabolisms and redox state between ~3.3 and ~2.2 Ga. Mineralogical and chemical compositions vary greatly: Fe (1~35 wt.% as total Fe), S (0~4 wt.%), and C_{org} (0~12 wt.%). C_{org}-rich rocks have strongly negative and variable $\delta^{56}\text{Fe}$ values (-2.3 to +0.6‰), where the most negative $\delta^{56}\text{Fe}$ values are restricted to samples where $\delta^{13}\text{C}_{\text{org}} < -35$, down to -50‰, suggesting that Fe³⁺ reduction may have been driven by methanogens in these samples. $\delta^{34}\text{S}$ and $\delta^{56}\text{Fe}$ values for these samples are negatively correlated, where $\delta^{34}\text{S}$ values as high as +15‰ suggest bacterial sulfate reduction under sulfate-limited conditions, consistent with an important role for methanogenesis. The negative $\delta^{56}\text{Fe}$ values, however, indicate that reactive Fe³⁺ was not limited. These relations provide powerful evidence that low- $\delta^{56}\text{Fe}$ Archean sedimentary rocks do not owe their origin to a low- $\delta^{56}\text{Fe}$ Archean ocean via extensive precipitation of oxides, as has been proposed, but instead reflect major biogeochemical cycling processes.

In contrast, S- and C_{org}-poor samples have restricted $\delta^{56}\text{Fe}$ values (-0.6 to +0.2‰), higher $\delta^{13}\text{C}_{\text{org}}$ values (-35 to -25‰), and modestly positive $\delta^{34}\text{S}$ values (0 to +5‰). The Fe budget in these samples is dominated by detrital components, and C_{org} and S isotope compositions record a component of photosynthesis and bacterial sulfate reduction, respectively. Some of these rocks have high Fe³⁺/Fe²⁺ ratios, suggesting significant oxidation at ~3 Ga.

Collectively, these results provide evidence for a diverse biosphere in the Archean that involved a consortium of microbial communities that included cyanobacteria, sulfate-reducing bacteria, and methanogens/ methanotrophs; bacterial Fe³⁺ reduction may have been driven by dissimilatory iron reducing bacteria, sulfate-reducing bacteria, methanogens/ methanotrophs, or a combination of these. The significant inventory of Archean sedimentary rocks that have highly variable C_{org}, S, and Fe isotope compositions indicates that extensive microbially-mediated redox cycling of Fe, S, and C_{org} occurred in the Archean-Paleoproterozoic oceans. The Archean oceans could have been at least temporally, locally, and slightly oxygenated in order to form and retain sulfate and reactive Fe³⁺. Therefore the oceans between ~3.3 and 2.2 Ga must have been, to some degree, stratified in redox state.

In situ isotope analysis of Fe in pyrite using laser ablation-ICPMS

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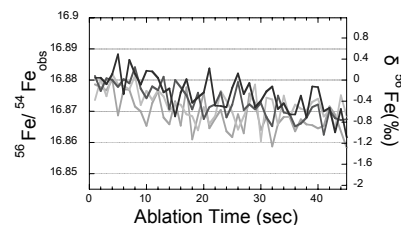
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Introduction

Iron isotope provides us various key information about how the oxidative-reductive circumstance of the very dawn time was. Pyrite (FeS₂) is the most important mineral in sediments because of several unique features such as chemical robustness through mechanical transmutation or secondary metamorphic events. In order to derive precise and reliable Fe isotopic data from pyrite, recently developed laser ablation-ICP-mass spectrometry (LA-ICPMS) has been widely employed (Horn *et al.*, 2006). However, in-situ isotopic analysis of Fe from pyrite using the LA-ICPMS technique has been retarded mainly because of poor analytical sensitivity and repeatability of the isotopic ratio measurements. It is widely recognised that the deterioration in analytical sensitivity and precision can be attributed to redeposition of sample around the laser ablation pit, and the measured isotope ratios (e.g., ⁵⁶Fe/⁵⁴Fe) changed through ablation time (Jackson and Gunther, 2006, Hirata *et al.*, 2005). In order to improve the reliability and precision of the Fe isotopic ratio measurements, resulting precision and accuracy of the ⁵⁶Fe/⁵⁴Fe ratio data obtained by the LA-ICPMS technique were rigorously tested.

Method

The graph below illustrates the changes in measured ⁵⁶Fe/⁵⁴Fe ratio against ablation time obtained by laser ablation of pyrite sample, demonstrating the isotopic fractionation (ca. 1‰ level) through laser ablation.



Series of experiments revealed that mass bias factor on ⁵⁶Fe/⁵⁶Fe ratio measurement was seriously dependent upon the amount of sample re-deposition around the ablation pit. In this paper, we will describe the new approach to minimize the isotopic fractionation using a femto-second laser ablation system.

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Sulfur system in anoxic confined aquifers in the northeastern Osaka Basin, Japan

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We used $\delta^{34}\text{S}$ values and chemical compositions of groundwater to investigate the influence of sulfate reduction and sulfide oxidation processes in a confined aquifer system in the northeastern Osaka Basin (NEOB), central Japan. Shallow confined groundwater (<100 m) in the basin is recharged mainly from mountainous areas to the north, and flows south and southwest through the aquifer system. Anion composition of the groundwater is dominated by HCO_3^- throughout the basin. However, concentrations of redox-sensitive species such as dissolved oxygen, NO_3^- , Fe^{2+} , and Mn^{2+} show that groundwater conditions become increasingly anoxic along the flowpaths. Moreover, $\text{SO}_4/(\text{SO}_4 + 2\text{HCO}_3)$ molar ratios decrease with increasing $\delta^{34}\text{S}$ along the flowpaths, which demonstrates that sulfate is reduced in the NEOB aquifer system. Groundwater with both high total dissolved solids and high SO_4 content was observed mainly in areas down-flow from faults. Because of the high SO_4 content, the anion composition of this groundwater cannot be adequately explained by a simple sulfate reduction process. A Rayleigh distillation model with $\varepsilon = -20\%$, which allows for sulfide oxidation within marine sediments in proximity to faults, explains the chemistry of all groundwater samples, including those with high SO_4 content. The model demonstrates that 76% of initial sulfate is reduced at maximum, and that reduced SO_4^{2-} content is up to 48.5 mg/L after sulfide oxidation in the NEOB aquifer system.

Adsorption and coprecipitation behaviors of platinum(II) complex ions on and with manganese(IV) dioxide and manganese(II) hydroxide: Model reactions for the concentration mechanism of platinum into oceanic manganese nodule

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In oceanic manganese nodule and crust, platinum (Pt) is more concentrated than sea water and earth's crust. However, the concentration mechanisms of Pt and its chemical state have not been clarified because of its extremely low concentration. From thermodynamic investigation, Pt is considered to be present as Pt(II) complex ion ($[\text{PtCl}_{4-n}(\text{OH})_n]^{2-}$) in deep ocean water. Therefore, we investigated the adsorption behavior of Pt complex ions ($[\text{PtCl}_{4-n}(\text{OH})_n]^{2-}$) on manganese(IV) dioxide ($\delta\text{-MnO}_2$) and the coprecipitation behavior of Pt complex ions with manganese(II) hydroxide ($\text{Mn}(\text{OH})_2$) as model reactions for the concentration mechanisms of Pt into manganese nodules and crusts. $\delta\text{-MnO}_2$ and $\text{Mn}(\text{OH})_2$ that is finally oxidized to manganese(IV) dioxide by dissolved oxygen are regarded as model compounds of manganese nodule and crust.

Pt(II) complex ions were vigorously adsorbed on $\delta\text{-MnO}_2$. The XPS and XANES spectra for Pt showed that the Pt(II) complex ions adsorbed on $\delta\text{-MnO}_2$ were oxidized to Pt(IV). Based on the analytical result of EXAFS spectrum, the Pt(IV) was present as PtO_6 species, suggesting that the adsorbed Pt(II) may be oxidized and substituted with Mn(IV) in $\delta\text{-MnO}_2$. Pt(II) complex ions were also coprecipitated effectively with $\text{Mn}(\text{OH})_2$. The Pt(II) may be oxidized to Pt(IV) after the oxidation of $\text{Mn}(\text{OH})_2$ to MnO_2 .

In conclusion, the concentration mechanism of Pt into manganese nodule and crust can be deduced as oxidative substitution by the redox reaction between Pt(II) in $[\text{PtCl}_{4-n}(\text{OH})_n]^{2-}$ and Mn(IV) in manganese(IV) dioxide.

Transition from MORB through intermediate type to IAT magmatism in the northern Oman ophiolite

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Wadi Rajmi area in the northern Oman ophiolite had been recognized as an "anomalous" crustal section in the Oman ophiolite, including the dike swarms crosscutting sheeted dike complex and large occurrence of gabbronorite (e.g. MacLeod & Rothery, 1992). In this area, the crustal section shows over 7km thick sequence consisting of layered gabbro, layered wehrlite, heterogeneous gabbronorite, isotropic diorite-tonalite, foliated gabbro, isotropic and pegmatitic gabbro, sheeted dike complex and pillow lava, from bottom to top. Besides three boninitic dike swarms are found from this area, and they are intruding into lower crust to pillow lava. Layered wehrlite, heterogeneous gabbronorite and isotropic diorite-tonalite are regarded as the late intrusive complex intruding into layered gabbro and foliated gabbro. Layered gabbro blocks rarely appear in heterogeneous gabbronorite. The boninitic dike swarms crosscut all earlier plutonic rocks including the late intrusive complex and dikes.

Based on mineral and bulk chemistry, we could distinguish three types of magma products (MORB, IAT and intermediate type) in the crustal sequence of Wadi Rajmi area. Trace element and REE contents of the boninitic dike swarms indicate a very low-Ti ($\text{TiO}_2 = 0.14\text{-}0.61$ wt.%) and a depleted spoon-like chondrite-normalized REE pattern ($\text{La}_N/\text{Sm}_N = 0.63\text{-}1.67$). These characteristics indicate that the boninitic dike swarms have IAT affinities and some of these have high-Ca boninite affinities. Clinopyroxenes from the boninitic dike swarms are a very low TiO_2 (<0.33 wt.%) in consistent with the bulk rock characteristics. Clinopyroxenes from gabbronorite indicate slightly lower TiO_2 content (0.05-0.74 wt.%) than those of layered gabbro and foliated gabbro ($\text{TiO}_2 = 0.18\text{-}0.91$ wt.%; corresponding to MOR gabbro). Clinopyroxenes from layered wehrlite have a very low TiO_2 content (0-0.15 wt.%) and REE patterns which are comparable with those of boninitic dike swarms. These mineral chemistry of the late intrusive complex indicate that these rocks crystallized from intermediate type magma between MORB and IAT.

The occurrence of three types of magma suggests that the tectonic setting of the Oman ophiolite was changed from accretion stage of MORB oceanic crust at mid-ocean ridge through reconstruction stage of oceanic crust by intrusion of intermediate type magma to IAT magmatism stage (subduction related magmatism).

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2.7 Ga Re-Os age for C-rich slate of the Joy Lake sequence, western Wawa subprovince, Minnesota

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Re-Os dating of carbonaceous rocks using $\text{H}_2\text{SO}_4\text{-CrO}_3$ dissolution [1] provides a powerful new geochronologic tool for application in Archean terranes. Using this method, we determined ages of ~2.7 Ga for C-rich slates in the Joy Lake sequence, the oldest Re-Os ages yet reported for C-rich sedimentary rocks. The Joy Lake supracrustal sequence (western Wawa subprovince, Superior province, north-central Minnesota) consists of volcanic and sedimentary strata with intercalated mafic tuff lenses, intruded by layered peridotite-pyroxenite-gabbro sills of the Deer Lake complex. Poor exposure and lack of geochronologic data for this sequence hinder construction of a geologic framework for the Wawa supracrustal rocks, compromising correlation with other sedimentary sections in the Superior province.

Carbonaceous slates of the Joy Lake sequence have well-developed cleavage subparallel to bedding and contain nodules, disseminations, and bedding-parallel stringers of pyrite [2]. Samples from two drill holes (DH26503 and DH26506) yield isochron ages of 2695 ± 14 Ma and 2684 ± 16 Ma and initial $^{187}\text{Os}/^{188}\text{Os}$ (Os_i) of 0.15 ± 0.16 and -0.29 ± 0.20 , respectively. The ages, identical within uncertainty, are consistent with ages for Timiskaming-type sequences in the Wawa (~2688 to 2695 Ma) and Abitibi subprovinces (~2677 to 2680 Ma) [3,4], that represent late-orogenic deposits and likely postdate the Joy Lake sequence.

A chondritic Os_i (0.109 at 2.69 Ga) is expected in Archean shales [5], but the negative Os_i for DH26506 requires explanation. Re may have been released from intercalated high Re/Os mafic tuffs during recent exposure and local oxidation. The C-rich rocks are a ready sink for mobile Re. This could shift isochron data points to higher $^{187}\text{Re}/^{188}\text{Os}$ with minimal slope change, increasing scatter and uncertainty for the Os_i . This would shift the isochron to the right, producing a spuriously low or negative Os_i intercept. If the Re addition is recent, the age is not affected. Notably, the shales in DH26506 are in direct contact with pyroxenite [2].

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Geochemistry and origin of black shale hosted Ni-Mo-PGE-Au mineralization in south China

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Most of the world's PGE mineralizations are mainly associated with mafic intrusions. There is, however, increasing evidence that economic levels of PGEs can be found in other environments. In this regard, the black shale-hosted PGE deposit has recently become a promising important source of PGE and many other metals in the world.

In the Yangtze Platform of South China occurs a thick sequence of metal-rich black shales of Neoproterozoic to early Cambrian age. An extreme multi-metal enriched sulfide ore bed has been identified in the lowermost strata of the Niutitang Formation in Lower Cambrian. Compared to average upper continental crust value, this multi-metal rich ore layer contains >10,000 times enrichment in Re and Os, and >1,000 times enrichment in Pt, Pd, Ag, and Au. In recent years, we have conducted a detailed geochemical and isotopic investigation in an attempt to decipher the depositional environments, to trace the source of metals, and to establish a ore genetic model for this special type of mineralization. Our Re-Os and Pb-Pb isotope dating of the black shales and sulfide ores suggested an age of ~530 Ma for deposition of the black shales and Ni-Mo-PGE-Au mineralization. A detailed trace element study shows that both the sulfide ores and their host black shales share similar element distribution patterns with pronounced depletion in Th, Nb, Hf, Zr, Ti, and extreme enrichment in U, Ni, Mo, and V compared to average upper crust. The high field strength elements such as Zr, Hf, Nb, Ta, Sc, Th, rare earth elements, Rb and Ga show significant interelement correlations and may have been derived mainly from terrigenous sources. The redox sensitive elements such as V, Ni, Mo, U, and Mn; base metals such as Cu, Zn, Pb; Sr and Ba may have been derived from mixing of seawater and venting hydrothermal sources. The chondrite-normalized REE patterns, positive Eu and Y anomalies, and high Y/Ho ratios for the Ni-Mo-PGE-Au sulfide ores are suggestive for a submarine hydrothermal-exhalative origin. Hence, we suggest that this type of mineralization is different from the magmatic-hydrothermal or epithermal origins as proposed for some black shale hosted PGE-Au mineralization elsewhere. A modern analogue of such type deposit could be organic-rich sediments of the Bering Sea, which are known to have high PGE concentrations.

Using isotope geochemistry to trace the origin of ore forming materials in the Jiaodong gold province, China

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The Jiaodong gold province is the most important gold concentration area in China and the largest hydrothermal vein gold producing area in the world. For tracing the origin of oreforming materials in this region, we integrated and analyzed the composition of sulfur, lead and strontium isotopes in the major gold ore deposits and the host late Archean Jiaodong Group, Mesozoic Linglong biotitegranite and Guojialing porphyre granodiorite.

The value of $\delta^{34}\text{S}$ in the Jiaodong Group is 4.7‰ in average and ranges from 3‰ to 10‰. This in the Mesozoic granites is 7.4‰ and 6‰-10‰, respectively. The $\delta^{34}\text{S}$ of gold ore ranges from 4.0‰ to 11.8‰, and shows a tower distribution. The value of $^{206}\text{Pb}/^{204}\text{Pb}$ in the Jiaodong Group, Linglong biotite granite and Guojialing porphyritic Granodiorite ranges from 16.111 to 18.025, 17.143 to 17.288 and 16.408 to 17.851, respectively. The value of $^{207}\text{Pb}/^{204}\text{Pb}$ in the three geologic bodies varies from 15.043 to 15.762, 15.413 to 15.456 and 15.342 to 15.581, respectively. The value of $^{208}\text{Pb}/^{204}\text{Pb}$ in the three geologic bodies is 36.752-38.824, 37.625-37.855 and 36.645-38.394, respectively. The initial ratio of Sr in the Mesozoic granite, gold ore, altered rocks or minerals and fluid inclusions ranges from 0.706 to 0.711, 0.709 to 0.712, 0.703 to 0.713 and 0.710 to 0.716, respectively.

Similarity exists in isotope components among gold deposits and host rocks. This indicates that the oreforming material is the mixture between crustal and mantle. The gold deposits may be formed in the relative close environment, where had no large scale intrusions entering in continental crust.

Noble gas isotopic ratios of volcanics and xenoliths from northern Taiwan-Luzon Arc

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The Taiwan-Luzon Arc, which was generated in response to the subduction of the South China Sea Plate, is currently colliding with the eastern margin of the Eurasian continental plate at the arc's southern and northern ends. Systematic temporal and spatial variations in the geochemistry of the magmas erupted along the arc are ascribed to the involvement of the subducted continent-derived sediments or crustal slivers close to the collision zones.

Three ³He/⁴He ratios of hornblende, biotite and pyroxene separated from the arc volcanics near the collision zone were obtained. The ratios of Hsiaolanyu lava from northern arc are less than 2.3 and 1.3 times atmospheric ratios (Ra). The other is 3.0 Ra of Mt. Arayat lava from southern part of the Taiwan-Luzon arc. This implies that the crustal component played an important role in the petrogenesis of the arc magmatism, at least near the collision zone, to the lower down the ³He/⁴He ratios of the lavas.

The helium isotopic ratios of olivines from xenoliths of Lanyu, Batan and Diogo island fall in a range from 8.1 to 10.1 Ra. They are close to the value of the average MORB ratio. However, the co-existing amphibole from the same nodule of Batan Island (8.4 Ra of olivine) shows a much lower ratio of 4.7 Ra, which are similar with the ratios of the arc lavas. In addition, pyroxenes and amphiboles from gabbroic xenoliths of the arc lavas exhibit a wide range from 2.3~7.6 Ra. It infers that they are cumulates in origin at different stages of fractionation in former magma chamber.

Combined with the Sr-Nd-Pb and helium isotopic data, we can conclude that at least two components, i.e., crustal component (Ra<1) and MORB component (Ra ~8), are necessary for the generation of Taiwan-Luzon arc magmatism.

Tracing water exchange between mantle and continental crust with the δD values of NAMs in granulite

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Introduction

A poorly defined parameter of the inner Earth water budget is the possible flux through the mantle and continental crust boundary. Therefore, in the aim to obtain new constraints on Mantle-Crust exchange, we undertook to determine the D/H ratio of granulites from North China Craton.

Results

3 set of granulites were analyzed: Archean-early proterozoic granulite xenoliths from Nushan, granulite from Hannuoba archean terrain, and phanerozoic granulite xenoliths from Hannuoba, for which the water contents have been previously determined by FTIR spectrometry (Xia *et al*, 2006 and Yang *et al*, submitted), with value ranging from 150 ppm up to 2300 ppm. The CRPG IMS 1270 ion microprobe were used for D/H ratio in situ measurements of Cpx, Opx and Plag. Measurements were performed with a 0' 10 μm diameter primary beam, and calibrated against already known NAMs and hydrous minerals. The δD_{SMOW} values obtained for Plag of the 3 samples set range from -80 to -150, for Opx from -150 to -100 for Nushan, -150 to -50 for Hannuoba Terrains and -100 and -20 for Hannuoba xenoliths and all the measurements on Cpx range from -60 to +20.

Discussion and conclusion

The high δD values observed for Cpx suggest that Cpx were affected by a diffusion hydrogen loss, as well as some Opx from Hannuoba. The preferential loss of hydrogen from Opx and then Cpx may be associated to their high initial water and iron content, both supporting H loss. Therefore the initial granulite δD values should be the one preserved in Plag and part of the Opx, and is similar in the 3 localities, mostly ranging in between -100 and -150. This low δD value may reflect either a lower continental crust or a deep mantle plume signature, but significantly differ from the expected composition of the upper mantle (-60 to -80). This suggests that not any water flux affected the granulite H isotopic composition, even for the Proterozoic granulite from Nushan that were transported to the surface during Cenozoic volcanism.

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Study on fluid inclusions of volcanic rocks in Songliao basin: The significance for natural gases

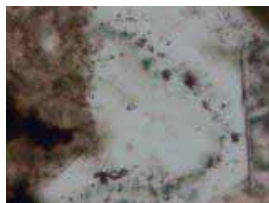
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Introduction

The Songliao basin is the largest sedimentary basin in China with most significance in producing oil and natural gases. In recent years, Chinese geologists found and explored the natural gases genetically linked to Mesozoic volcanic rocks in this basin (Qin *et al.*, 2001). Three types of volcanic rocks have been identified in the basin, which are basaltic igneous flows, andesite and rhyolite. All those volcanic rocks are richness in fluid inclusions (Fig.1). The widely spreading of Mesozoic-Cenozoic volcanic rocks along Tan-Lu fault belt in east China and the gas-liquid compositions from fluid inclusions are drawn great attention to geochemists. This study



focus on the compositions of fluid inclusions bearing in these different volcanic rocks series.

Fig. 1 Typical fluid inclusions bearing in quartz of an andesite in the Songliao basin

Experiment and Results

The chemical compositions of fluid inclusions are determined with RM-1000 laser Raman spectroscopy produced by Renishaw Company at Institute of Geology & Mineral Resources, Xi'an. The results show that most of the fluid inclusions are mainly composed of CO₂, CH₄, CO, H₂, N₂, H₂S and SO₂. The relative high concentrations of CO₂ in fluid inclusions are correspondent to funding of CO₂ reservoir with inorganic genesis widely distributed in different sub-sags of the basin in the past decade. In contrast, the other components in fluid inclusions among the combustible CH₄, CO and H₂ consist of main components of the natural gases explored in the basin. The compositions of fluid inclusions of volcanic rocks are also good proxies to trace the mantle degassing since Mesozoic in east China.

Acknowledgment

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Different accumulation of Pb, Zn, and Cd in river sediments and in lake sediments originated from ancient zinc smelting activities in northwestern Guizhou, southwestern China

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Zinc smelting in northwestern Guizhou, southwestern China resulted in significant heavy metal accumulation in sediments. In this study, river sediments were collected in a river in the smelting region, and lake sediments were collected in a lake ca. 10km downwind from zinc smelters. Concentrations of Pb, Zn, and Cd in the river sediments varied greatly in the range of 4,375-21,850, 7,275-30,425, and 42.0-95.0 mg kg⁻¹, averaging in 14,022, 24,441, and 72.9 mg kg⁻¹, respectively. Ratios of Pb/Cd and Zn/Cd in river sediments were in the range of 104-266 and 173-390, respectively. However, Concentrations of Pb, Zn, and Cd in lake sediments were in the range of 66.0-160, 130-1200, and 2.60-71.0 mg kg⁻¹, averaging in 99.7, 536, and 26.0 mg kg⁻¹, respectively. Ratios of Pb/Cd and Zn/Cd in lake sediments varied narrowly in 2.14-25.4 and 16.9-50.0, respectively. Normally, Pb, Zn and Cd accumulated vertically in the lake sediments in the depth of 0-15cm, and then their concentrations dramatically decreased to sediment baselines. In river sediments, Pb was mainly in carbonate bound fraction (35-51%) and iron and manganese bound fraction (26-47%); Zn was in carbonate bound fraction (32-39%) and iron and manganese bound fraction (38-48%); whereas Cd in residue fraction (16-59%) and carbonate bound fraction (15-45%). However, in surface lake sediments, organic bound fraction was the dominating chemical forms of Pb (34-82%), Zn (3.8-46%), and Cd (31-84%); while residue bound fraction accounted for 14-39% for Pb, 17-69% for Zn, and 4.0-55% for Cd, respectively. High organic matter content (14-45%) may reasonably explain high concentrations of organic bound metals in lake sediments. In river sediments, ²⁰⁶Pb/²⁰⁷Pb, ²⁰⁶Pb/²⁰⁸Pb ratios varied in 1.182-1.185, 0.399-0.403, respectively; however, in lake sediments, these ratios were in the range of 1.178-1.2202, 0.477-0.486, respectively. These results suggested that Pb, Zn, and Cd in river sediments were from release of zinc smelting slags, however, in lake sediments, they were originated from dust deposition of zinc smelting emits. Elemental fractionation during smelting may cause big differences in Pb/Cd and Zn/Cd between river sediments and lake sediments.

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Some anaerobic microbial communities in peat bogs and the influence on the biogas formation

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Microorganisms play important roles in the transformation of peaty organic matter. The interplay between organic matter transformation and microbial activities is complex in the peat environment and the underlying mechanisms or pathways for carbon cycling may vary from case to case. The goal of this study was to investigate distribution of anaerobic microbial communities under varying geological or chemical conditions in different peat environments, and search for patterns of microbial organic carbon transformation under varying organic matter types conditions by simulate experiment. Samples were collected from mangrove bog (modern to 10,000 years) in Hainan province and from burial peat (Holocene) in Yunnan province of China. Content of total organic matter ranged from 27.6% to 55.7%.

There are four kinds of main advantage germ clusters in the peat bogs including fermentation bacteria, anaerobic cellulose-degrading bacteria, sulfate-reducing bacteria and methane-producing bacteria. Fermentative bacteria (10^4 to 10^6 cells/g) based on MPN were significantly higher than sulfate-reducing bacteria or acetogens ($< 10^3$ cells/g) in all peat samples. The distribution or number of fermentative bacteria to some extent correlated positively with the organic matter content (e.g., humic acids) in some but not all samples, suggesting that organic matter content may not be the only factor controlling the population of fermentative bacteria. We focused on fermentative bacteria because they play a critical role in transforming cellulose organic matter to smaller organic molecules bio-available to other dissimilatory microorganisms such as sulfate-reducing bacteria or methanogens.

On the other hand, fermentative bacteria create anaerobic environment, which removes oxygen and enriches hydrogen in the organic matrix. By concentrating and purifying the advantaged species of the fermentation bacteria, we culture the advantaged germ in different matrix. Highly nutritious peat environment could be simulated and then the bacterial-degradation experiments of plant may be controlled well. The experiment has already carried on for 6 months, The degrader of Fermentation bacteria causes that organic matter from the plant lost a great deal of oxygen, and cause the matrix enrich more hydrogen. we can also know that the production rate of bacteria-degrading biogas is 5-10 times larger than the production rate of hydrolysis gas without bacteria. Thus fermentative process may help enhance the quality of organic carbon preserved as fossil fuel in geological formation.

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Extreme fractionation of low salinity magmatic fluids

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Most crustal magmatic fluids are predominantly chloride solutions, but in certain situations, notably in some granite pegmatites, water-rich fluids occur which have low salt contents (<seawater salinity). The consequences of low salinity include higher gas solubilities, resulting in potentially higher bicarbonate levels, and low concentrations of Ca, permitting higher concentrations of additional ligands such as fluoride and phosphate. LA-ICP-MS analysis provides a means of determining many of the significant pegmatite components in single inclusions, and has been carried out in Leeds using a Geolas Q laser ablation system (193nm ArF Excimer laser) coupled to an Agilent 7500c ICP-MS. Calibration is with glass SRMs and with solutions loaded in capillaries.

Fluid inclusions from the quartz core of the Muiane Li-pegmatite, Mozambique (sampled by O. Von Knorring), are 3 phase at room temperature, with CO₂ liquid and vapor. Large inclusions (25-60 μm) are common. LA-ICP-MS analysis of individual inclusions reveals significant variations within texturally similar settings, and in particular Na/K (wt) ranges from <1 to >15. Extreme enrichment in Cs (to >2000 ppm) and Li (to c.3000 ppm) is associated with high Na/K ratios and possibly arose as K-feldspar and micas were precipitated. Such fluids are also enriched in B (to c.3000ppm). Not surprisingly, spodumene is a major mineral in the deposit and pollucite has been reported. Some high Na/K fluids are very rich in As (>25000ppm), while others contain only a few thousand ppm As. A solid As daughter phase has been observed in a few very large inclusions.

The results are taken to indicate that in the final stages of magmatic fluid evolution, extreme fractionation effects can be produced, reflecting the growth of new solid phases. However vapour-liquid separation may play an important role in the development of the decoupled As-enrichment.

The influence of minor elements on melting of eclogite in the mantle

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An important role for recycled mafic crust in upper mantle magma-genesis is frequently postulated. Models vary between those in which siliceous to basaltic melts from minor mafic heterogeneities in peridotitic upper mantle are extracted directly from their upper mantle source regions without significant interaction with peridotite wall-rock before eruption, to those which postulate reaction and resorption into enclosing peridotite of siliceous partial melts from eclogite or pyroxenite, resulting in refertilisation of the peridotite and formation of new, opx-enriched lithologies. Melting of these refertilised peridotites provides the erupted magmas.

Critical to testing these opposing models is detailed knowledge of the partial melt products of mafic lithologies at high pressure. We report experimental investigations of high pressure melting of volatile-free eclogite and carbonate-bearing eclogite, focussing on the importance of some minor elements in controlling subsolidus mineralogy, low degree melting relations and partial melt compositions.

We determined the phase relations and partial melt compositions of a nominally anhydrous altered MORB composition (GA2) with 49.7 wt% SiO₂, 0.37 wt% K₂O, 3.34 wt% Na₂O, 0.23 wt% P₂O₅ and 1.82 wt% TiO₂, from 3-5 GPa and 1200-1600°C. We identify two distinctive melting regimes. Low degree melting ($\leq 20\%$) is eutectic-like and is dominated by contributions from accessory phases (K-feldspar, rutile, quartz/coesite and possibly apatite), with additional components from garnet and clinopyroxene. At 3 GPa K-fd, rt and qz are residual phases up to about 40°C above the solidus, but at higher pressures K-fd and rt melt out close to the solidus. At higher degrees of melting, once accessory phases are melted out, melt compositions are controlled by melting along ga-cpx cotectics. Low degree melts are dacitic and trend towards andesitic and basaltic andesitic with increasing temperature. At 3 GPa Na, Ti and K are incompatible, but at 4 and 5 GPa Na becomes compatible, yielding increasingly fractionated Na/Ti and Na/K in melts.

Similar dual melting behaviour is observed in partial melting of Ca-Mg-carbonate-bearing eclogite, where low degree partial melts are sodic calcio-dolomitic to dolomitic and are controlled by eutectic melting relations on the calcite-magnesite join, with minor contributions from ga + cpx. Increasing degrees of melting, or melting of residues after carbonate melt extraction, result in progressively more siliceous partial melt compositions. Interactions between these carbonated melts and peridotitic wall rock could generate a spectrum of enriched source lithologies suitable for some magmas.

Heavy metal concentrations in soils and tea plants in Sürmene and Çayeli area (NE -Turkey)

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The study area covers two geologically different regions which have intensively been carpeted by tea plants in the Eastern Black Sea. The rocks exposed in the region contain considerable amount of trace metals due to Upper Cretaceous massive sulfide formations and Tertiary epithermal mineralizations. Tea plants grow over the soils derived from such mineralized rocks indicate different concentration in Cu, Pb, Zn, Fe, Cd, P, Al, Na, K, S. Most of the analyzed elements except Al shows higher content ratios in basaltic and sedimentary rocks. Al content is found to be high only in tea plants grow on the dasitic rocks.

The highest average Cu values (26.17 ppm) occur in tea plants in Çayeli area. Pb reaches the highest value in Çayeli (1.94 ppm) in tea plants. The highest Cu, Pb, Zn concentrations were recorded in soils at Sürmene area whereas the highest Al (7.56 %) concentration was observed in Çayeli. The soils in Sürmene area sampled during first sprout period of tea plants contain relatively high amount of Cu.

In order to better understand the element distribution processes in tea plants, some experimental studies were undertaken. Young tea plants were planted in small boxes and were applied with Cu, Zn, Cd and Mn element complexes and fertilizers. The effect of fertilizers in element mobility was found to be significant. Especially Ammonium sulfate fertilizer increased element uptake of tea plants by lowery pH. Bioavailability coefficients of the applied elements are as follows, Cu: 0.14, Zn: 0.18, Cd: 2.45 and Mn: 0.15. The differences in the amount of irrigation played an important role in bioavailability and uptake of elements both in soil and tea plants. Cu, Zn, and Mn are relatively easily uptaken by the tea plants from the soils often watered. The amount of water has no effect on Cd uptake.

The Pb concentration sharply decrease from road side (1.08 ppm) to 100 m in land (0.37 ppm).

Geochemistry of biotites in Ali-Abad and Darreh-Zereshk porphyry copper deposits, Yazd, Central Iran

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Darreh-Zereshk and Ali-Abad are two relatively small porphyry copper deposits in Central Iran. The biotite compositions used to interpret nature, physicochemical conditions of magma source and petrogenesis of these granitoid rocks. Biotites from granitoids of the Aliabad-Darreh Zereshk areas are green and brown types. On the basis of IMA classification, these biotites can be classified mainly as phlogopite on the basis of ratios of $100 \text{ (Mg / (Mg + Fe))}$ which vary between 17 and 22. Also, plotting of $100\text{Fe}_t / (\text{Fe}_t + \text{Mg})$ ratio of the studied biotites on a stability diagram correspond to temperature about 600 to 750°C and confirming magmatic origin for these biotites. In addition, biotite composition used for discrimination of the granitoid magma. The chemical composition of studied biotites show that the granitoids of the Aliabad-Darreh Zereshk areas are calc - alkaline I-type.

The main substance constitutes and chemical composition characters of the dust in the urban district of Beijing

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With the development of urbanization, industrialization, population growth, and traffic growth, the environmental pollution has been more serious in the city. The statistic shows that one third of the population live in the city. The study of heavy metals' characters and migration in the city is of highly important and practical because of its toxicity and accumulation in organism. The dust in the urban area tend to form a repeated cycle of rising and sinking under the action of external forces, and develop into particles that are likely to be breathed by human bodies, thus causing great harm to human health and environment.

Dust has been collected and studied as the medium carrying heavy metal pollutants. The dust samples are collected within the 4th Ring Road and the composition, chemicals and granularity was tested. The dust in the urban area is mainly composed of quartz, plagioclase, dolomite, calcite, and hornblende, which account for 80 to 90 per cent of all the minerals. Besides, there is a small quantity of mica, microcline, sericited feldspar, carbonaceous granule, glass, etc. The content of K_2O and Na_2O is higher in the coarse grains than in the fine grains. The averages of content of 16 elements are all higher in the fine grain than in the coarse grain. The sequence of the heavy metals from most seriously contaminates to the slightly contaminates in the dust are cadmium, mercury, zinc, copper and arsenic.

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The mantle neon from the Jinchuan sulfide deposit, NW China

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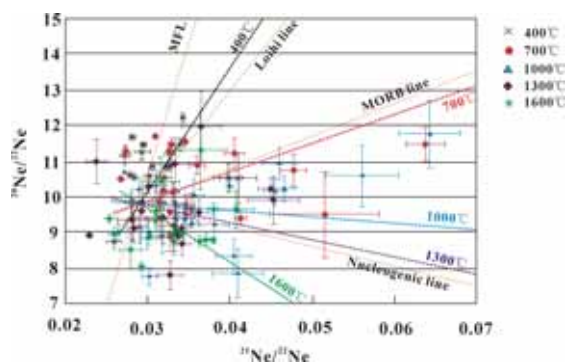
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The noble gas isotopic compositions in the clinopyroxene, olivine, orthopyroxene and chalcopyrite from the second diggings of the Jinchuan sulfide deposits, NW China, have been determined. Stepwise heating method had been taken in order to get the noble gas isotopic compositions from the different micro-sections in a sample. The ranges of the neon contents and isotopic compositions in the samples studied were shown in the following table.

Neon data ranges in the samples studied		
Temperature (°C)	²⁰ Ne/ ²² Ne range (average)	²¹ Ne/ ²² Ne range (average)
400	8.75—12.22 (10.58)	0.02594—0.04100 (0.03125)
700	9.39—11.705 (10.39)	0.02669—0.06380 (0.03636)
1000	7.77—11.77 (9.64)	0.02649—0.06430 (0.03795)
1300	7.81—11.97 (9.62)	0.02292—0.04530 (0.03275)
1600	8.04—11.30 (9.22)	0.02536—0.04070 (0.03289)
Total	9.00—11.368 (10.02)	0.02697—0.04400 (0.03361)

Apparently, the neon isotopic compositions of the samples were different from atmospheric. Higher ²⁰Ne/²²Ne values were found at 400°C and 700°C with an average of 10.58 and 10.39, respectively. In the three isotopes diagram of neon, the data points are dispersive, which shows a characteristic mixed on multi-member fluid. However, the data points are concentrated or show a correlation between ²⁰Ne/²²Ne and ²¹Ne/²²Ne at every temperature step. It is noticeable that the line at 400°C closed to Loihi line, the line at 700°C trends to MORB line, and the lines at 1000°C, 1300°C and 1600°C shown an addition of radiogenic neon. The fluids released at lower temperature were mainly come from fluid inclusion, so it is surmisable that the mineral captured mantle fluid during crystallization.



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A molecular model for microbial Se(VI) reduction

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Background

The redox cycling and mineralization of selenium is largely controlled by microbial processes. Phylogenetically diverse species of *Bacteria* and *Archaea* are able to reduce soluble selenate oxyanions [Se(VI), SeO₄²⁻] to insoluble elemental selenium [Se(0)]. Although Se-reducing bacteria are known to govern the redox transformation of selenium in a broad range of terrestrial and aquatic environments, the mechanisms of microbial selenate reduction remain poorly understood. In this study, we apply molecular techniques to identify the genes involved in selenate reduction pathway.

Methods

Transposon mutagenesis and direct cloning techniques were used to identify genetic regions in the Se-reducing bacterium *Enterobacter cloacae* SLD1a-1 associated with selenate reductase activity. The mini-Tn5 transposon system was used to produce mutants that have lost the ability to reduce selenate. *E. cloacae* mutants and genomic library clones heterologously expressed in *E. coli* S17-1 were screened for activity on LB agar supplemented with sodium selenate. The rate of selenate reduction by the clones was measured in liquid minimal media, and the Se(0) minerals formed by the clones were examined using XANES and SEM.

Results and Discussion

Essential genes required for microbial selenate reduction were identified. The experiments showed that mutation of the Fumarate Nitrate Reduction regulator gene, menaquinone biosynthesis operon, and twin-arginine translocation operon produces derivative strains that are deficient in selenate reductase activity. Complementation by the wild-type sequences restores the ability of mutant strains to reduce Se(VI). These results demonstrate that: 1) oxygen sensing molecules regulate the expression of selenate reductase genes; 2) selenate reduction activity is dependent on the secretion of the reductase enzyme to the periplasmic space; and 3) anaerobic electron carriers are involved in the shuttling of electrons to the terminal selenate reductase protein. We propose a molecular model to describe microbial Se(VI) reduction.

Metamorphic evolution and tectonic implications of the Qianlishan-Zhuozishan complex, westernmost part of the Paleoproterozoic Khondalite Belt in the Western Block of the North China Craton

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A major advance has been made in understanding the Paleoproterozoic amalgamation of the North China Craton at ~1.85 Ga following recognition of two Paleoproterozoic continent-continent collisional belts, named the Trans-North China Orogen and Khondalite Belt[1-2]. In the last few years, extensive work has been done on the Trans-North China Orogen[3-5], but few investigations have been carried on the Khondalite Belt in the Western Block, which has hindered the further understanding the tectonic amalgamation of the Yinshan and Ordos Terranes and the formation of the Western Block. In this study, we present metamorphic data for the khondalites in the Qianlishan-Zhuozishan Complex in the westernmost part of the Paleoproterozoic Khondalite Belt, which places rigorous constraints on the evolution of the belt and amalgamation of the Western Block. The Qianlishan-Zhuozishan Complex is composed predominantly of S-type granites and supracrustal rocks, including Al-rich gneisses, quartzites, marbles and calc-silicate rocks, collectively called khondalite series in the Chinese literature. Petrographic studies show that the Al-rich gneisses from the Qianlishan-Zhuozishan Complex underwent four distinct metamorphic stages. M1 is represented by quartz + plagioclase + muscovite + biotite + garnet core, forming at 550-650°C and 6-8 Kbar. The M2 stage formed sillimanite, garnet, cordierite, K-feldspar, plagioclase and quartz at the T-P conditions of 750-800°C and 6-7 kbar. It was then followed by the M3 stage that represents the formation of cordierite coronas surrounding garnet, indicating a nearly isothermal decompression. Finally, the rock experienced a retrogressive stage (M4) represented by the appearance of andalusite and late muscovite. These mineral assemblages and their approximate P-T estimates define a clockwise P-T path involving nearly isothermal decompression for the Qianlishan-Zhuozishan Complex, supporting the recently proposed model that the Western Block formed by the collision between the Yinshan and Ordos Terranes along the Paleoproterozoic Khondalite Belt.

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The source and distribution of volatile elements on Hadean Earth

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The Earth's atmosphere is an integrated product of planetary evolution processes that reflects the chemistry of the contributing materials (precursors) and the energy supplied. According to astrophysical models, potential precursors that could have delivered significant quantity of water or hydrogen to the primitive Earth include the solar nebula, comets and carbonaceous chondrite-like materials of different sizes (planetary embryos, micrometeorites and IDPs). The comparative study of H, N and C isotopic compositions between those potential precursors and the Earth suggests that a major source of highly volatile elements is carbonaceous chondrite-like material (e.g. Marty and Yokochi, 2006). As such components cannot be the major building blocks of the Earth, however, the mode and timing of their supply as well as the possible events having affected the water and other volatile elements need to be constrained in order to understand the evolution of the primitive Earth's surface environment. In this context, noble gases are advantageous tracers of physical processes and their time scales given that they are chemically inert and that several radiogenic isotopes of appropriate production rates exist.

Xenon isotopes indeed provide an exceptional set of chronological tracers: ¹²⁹Xe was produced by the now extinct β -decay of ¹²⁹I (T_{1/2}= 15.7 Myr), and ¹³¹⁻¹³⁶Xe were produced by the spontaneous fission of ²³⁸U (T_{1/2}= 4.45 Gyr) and now extinct ²⁴⁴Pu (T_{1/2}= 82 Myr). As the respective proportions of ²⁴⁴Pu and ²³⁸U fissions to ¹³¹⁻¹³⁶Xe isotopes are poorly constrained due to the similar relative yields, we determined the proportions of ²⁴⁴Pu and ²³⁸U fission derived ¹³⁶Xe according to the relative abundances of ⁴He-²¹Ne-¹³⁶Xe, for a set of new noble gas data obtained for Kola plume (Russia) samples (Yokochi and Marty, 2005). The ²⁴⁴Pu contribution of mantle plume-related component is estimated to be 33-60 % of total fission ¹³⁶Xe. This value is significantly lower than what is expected for a chondritic reservoir (96 %), and is similar to the previously proposed best estimate for the MORB mantle (32 ± 10 %). This result implies that the whole mantle was subject to degassing after the decay of ²⁴⁴Pu, over the entire Hadean. In line with this result, a model age of the atmosphere based on the ratio of radiogenic ¹²⁹Xe/⁴⁰Ar suggests that the atmosphere was subject to hydrodynamic loss over 150 Myr after solar system formation, much longer than previous model estimates using xenon isotopes alone.

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More on Os isotope anomalies in chondrites: Possible carriers

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Recent, highly-precise isotopic analyses of various bulk meteorites and acid residues have revealed that some primitive chondrites contain isotopically anomalous presolar grains which record diverse stellar nucleosynthesis. Another essential but still unsolved issue is whether or not the chondrite precursors, including presolar grains, were homogeneously distributed in the early solar nebula at the time of planetesimal formation. We have previously demonstrated that bulk samples of carbonaceous, enstatite and ordinary chondrites have uniform ¹⁸⁶Os/¹⁸⁹Os, ¹⁸⁸Os/¹⁸⁹Os and ¹⁹⁰Os/¹⁸⁹Os ratios when decomposed by an alkaline fusion total digestion method, although acid residues of some carbonaceous chondrites were enriched in Os isotopes produced by s-process nucleosynthesis [1]. These results suggest that chondrite precursors were thoroughly mixed in the early solar nebula, and we speculated that the main carrier of the anomalous s-process-enriched Os was presolar SiC grains. Reisberg *et al.* [2], similarly carried out sequential acid leaching of the bulk Murchison meteorite, and found that an s-process-enriched Os-rich component was accessible with mild leaches (e.g. hot HCl treatment). They proposed that the main carrier of the s-process Os may not be presolar SiC grains but rather more easily digestible presolar phases such as graphite or metal alloy.

To investigate this issue further, we have carried out a hot HCl leaching experiment for the Murchison acid residue prepared by a relatively mild CsF/HF technique. The bulk sample of this residue was strongly enriched in s-process Os ($\epsilon^{186}\text{Os}^i = +11.0$). The hot HCl leaching recovered ~10% of the Os in the residue, which was also enriched in s-process isotopes ($\epsilon^{186}\text{Os}^i = +8.0$) but not as high as the bulk residue. This indicates that the HCl insoluble phase in the residue is more enriched in s-process Os, corroborating the existence of acid resistant SiC grains as an s-process Os carrier. The leachate is known to have a ⁵⁴Cr anomaly, an isotope that can be produced by r-process nucleosynthesis [3]. Therefore, the leachate may contain an HCl digestible, r-process Os carrier, the existence of which may be masked by the HCl digestible s-process Os carrier. The likely hosts of the s- and r-process Os remain unclear. We will conduct further leaching tests (e.g. HNO₃, HClO₄) on the Murchison residue as well as other chondrite acid residues to better identify the carrier of isotopically anomalous Os in the chondrites.

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REE geochemical study on the formation environment of the Hishikari epithermal gold deposit, Japan

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In order to investigate the formation environment, especially redox environment, during the mineralization at the Hishikari epithermal gold deposit, Kagoshima prefecture, Japan, the concentration of rare earth elements (REE) and Y in the Hosen No.1 auriferous quartz vein were determined by ICP-MS after acid dissolution and selective separation.

The Hosen No.1 vein shows well symmetric banded structure and it was classified into four main bands (band I - IV). This vein was consisted of quartz, adularia and smectite associated with electrum and metal sulphides (e.g. pyrite, sphalerite and galena). Adularia could be commonly observed in each band, especially it is abundant in the earliest precipitation stage of each band. Electrum and other metal sulphides occurred with adularia and/or smectite. The quartz vein samples were collected from each band at -20 and +62.5 meter levels. The samples collected in the band II were analyzed separately by specific minerals due to the existence of electrum and sulphide-rich band called "ginguro" band.

The total concentration of REE including Y was varied from 9.72 to 0.45 and from 5.11 to 0.66 ppm at -20 and +62.5 meter levels, respectively. The highest concentration at each level was obtained in the samples obtained from the band II containing "ginguro". The chondrite normalized REE patterns of all the samples at both -20 and +62.5 meter levels showed a strong positive Ce anomaly. These results suggest that the Hosen No.1 quartz vein was precipitated and formed by mixing with oxidizing fluid (groundwater or meteoric water) and hydrothermal fluids after loss of H₂S and CO₂ gasses, and increase in pH due to boiling.

Mantle heterogeneity as evidenced by Raobazhai peridotite, North Dabieshan, China

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The peridotite bodies occurred near Raobazhai, in north Dabieshan trends northwestwards extending more than 10Km. The peridotite body consists mainly of harzbergite and dunite, with a few lherzulite mostly amphibolized due to amphibolite facies metamorphism. All of them are highly serpentinized. Major mineral paragenesis of the peridotites are Ol+Opx+Spl and Ol+Spl. The peridotite bodies are highly deformed and are mylonitized. REE distribution pattern and trace element geochemistry evidenced the chemical heterogeneity of these mantle-derived rocks.

There are a number of garnet pyroxenite enclaves scattered within the peridotite body as small pods, decimeters in size, enclosed in the serpentinized peridotites. Major mineral components of the garnet pyroxenite are: garnet (Prp₂₅₋₃₅), sodium augite (Jd₁₀₋₂₅) with a small amount of ilmenite. There are two stages of retro- metamorphism: the retrogressive granulite facies superimposed by amphibolite facies. On the basis of garnet-clinopyroxene geothermometry $K_d=4.06-5.28$; $T=793-919^\circ\text{C}$, $P=1.5$ Gpa are estimated for the garnet pyroxenite.

It is inferred that the peridotites are mantle rocks about 60Km in depth. During the exhumation of the orogenic belt it was tectonically emplaced into the lower crust in solid state and then uplifted to shallow depth. The REE distribution pattern and the Ni-Co-Sc diagram reveal that they are chemically equivalent respectively to the basaltic melt and ultramafic residua. Incomplete removing of mantle melting products from source area could be a possible mechanism for the mantle heterogeneity.

Si and Mg isotopic constraints on the astrophysics of CAI formation in the early solar system

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Silicon and magnesium isotope ratios can be used to constrain the pressure (P_{H_2}) and duration of melting of calcium-aluminum-rich inclusions (CAIs) in the early solar system. Recent results (Shahar and Young 2007) show that these primitive protoplanetary objects most likely melted for integrated timescales of tens of days at $P_{\text{H}_2} < 10^{-6}$ bar. Here we show that the isotopic compositions of CAIs further require that they formed not only at lower pressures than the more abundant chondrules with which they are found, but also at orders of magnitude lower number densities, constituting an important constraint on the astrophysical setting of CAI formation.

The substantial Si and Mg isotope fractionation in CAIs suggests that their number densities were too low to permit an overall elevation in background partial pressure of Mg and SiO that would have prevented fractionation. We quantify this effect by estimating the pressure of gas molecules or atoms i produced by a population of evaporating CAIs:

$$P_i^{\text{vac}} = \frac{3J_i r_o^2 t N_{\text{CAI}}}{(D_i^{\text{gas}} t)^{3/2}} kT \quad (1)$$

where N_{CAI} is the number of CAIs within a sphere defined by a radius equal to the characteristic length scale for diffusion in the gas ($D_i^{\text{gas}} t$)^{1/2} and J_i is the flux of an element i (e.g., Mg or SiO) from a single CAI. Modification of J_i by $(1+P_i/P_{i,\text{eq}})$ to account for deviations from vacuum and approaches to equilibrium vapor pressures results in the expression

$$\frac{P_i}{P_{i,\text{eq}}} = \frac{P_i^{\text{vac}} / P_{i,\text{eq}}}{1 + P_i^{\text{vac}} / P_{i,\text{eq}}} \quad (2)$$

For typical conditions indicated by Si and Mg isotope fractionation, including $T = 1673$ to 1873 K, $P_{\text{H}_2} = 10^{-9}$ to 10^{-4} bar, equations (1) and (2) yield a maximum number density of CAIs during their melting of 1×10^{-3} to 2.0 m^{-3} , or a linear spacing of > 0.8 to 8 meters. This number density is four orders of magnitude lower than that for chondrules (Young and Galy 2004; Cuzzi and Alexander 2006).

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Cenozoic volcanism of kamafugite and carbonatite in Western Qinling, China: Evidence of DUPAL-like asthenospheric mantle flow

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Dispersed Cenozoic potassic volcanism appeared over much of Tibet plateau and adjacent area during late stages of India-Eurasia plate collision and post-collision. Although widespread this volcanic activity appears to be distinct from that producing Large Igneous Provinces being characterized by greater compositional diversity and a lack of evidence for deep-mantle plumes. However, an additional feature is the dominance of DUPAL-like Pb isotopic compositions and ϵ_{Nd} in asthenosphere-derived melts, attributed variously to the influx of Indian Ocean mantle, endogenous mantle plumes or delaminated cratonic substrate. "Dispersed" volcanism may therefore pose fundamental questions concerning the dynamic behavior of sub-continental mantle in relation to continental plate collision. Is the asthenosphere mobilized during such plate collision? and to what extent and by which mechanisms are plate kinematics coupled to mantle flow? May be, the studies of Cenozoic Carbonatite and kamafugite in Western Qinling, China can answer the questions.

The kamafugite and carbonatite in Western Qinling, China located to the northeastern boundary of Tibet plateau. The volcanic rocks have the characteristics rich in LILE, LREE and HFSE (such as Nb,Zr,Th and U *et al.*) especially. The distribution patterns of REE chondrite-normalized is very like to OIB. Initial $^{87}\text{Sr}/^{86}\text{Sr}$ are lower (in the range of 0.70381-0.7094 for kamafugites, of 0.70529-0.71332 for carbonatites), initial $^{144}\text{Nd}/^{143}\text{Nd}$ (in the range of 0.512924-0.512404 for kamafugites, of 0.512928-0.512221 for carbonatites) are higher but homogeneous comparing to Sr isotopes of the volcanic rocks. A lot of volcanic rocks have their ϵ_{Nd} a range of -3.4- -5.58 and plot in the area of OIB's ϵ_{Nd} and have Dupal-like the Pb isotope composition. The major element chemical and Sr, Nd, Pb isotopic geochemical composition of the volcanic rocks also fall in OIB compositional area in the diagrams of $^{208}\text{Pb}/^{204}\text{Pb}$ vs $^{206}\text{Pb}/^{204}\text{Pb}$, $^{207}\text{Pb}/^{204}\text{Pb}$ vs $^{206}\text{Pb}/^{204}\text{Pb}$, MgO (wt%) vs Ni (ppm) and ϵ_{Nd} vs ($^{87}\text{Sr}/^{86}\text{Sr}$).

All of these mentioned above show that WQL Cenozoic kamafugites and carbonatites are a ultra-potassic volcanism related to mantle plumes and contained EM1 and EM11 end members in their mantle sources. Despite the apparent lack of plumes in the Western Qinling, the studies of Western Qinling Cenozoic volcanic rocks of kamafugite and carbonatite, and seismic tomography suggests the Cenozoic volcanism in Western Qinling is matched by swell-like low-velocity anomalies in the upper mantle or shallow-level perturbations of the asthenosphere. Spatial and temporal associations of the volcanism further suggest that discrete asthenosphere, i.e. so-called "crust-mantle transitional belt" were generated during late stages of the India-Eurasia continental collision.

Study of Lu-Hf geochronology - A case study of eclogite from Dabie UHP Belt

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We developed Lu-Hf isotope geochronology with isotope dilution multiple collector inductively coupled plasma mass spectrometry (MC-ICP-MS). Chemical separation of Lu and Hf from bulk rock is set up while the Lu cut of the chromatography contains Yb and $^{176}\text{Lu}/^{176}\text{Yb}$ is always larger than 30. The correction of Lu and Yb interference on Hf adopted in this work is based upon an exponential law although Lu and Yb concentration in the Hf cut is very low ($^{176}\text{Lu}/^{176}\text{Hf}$ and $^{176}\text{Yb}/^{176}\text{Hf}$ are less than 2×10^{-6} and 2×10^{-4} , respectively). Internal precision of $^{176}\text{Hf}/^{177}\text{Hf}$ measurements for natural samples is better than 0.0015% while the external precision is better than 0.0010%.

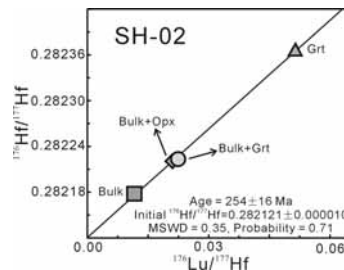


Fig 1 $^{176}\text{Lu}/^{177}\text{Hf}$ - $^{176}\text{Hf}/^{177}\text{Hf}$ isochron of eclogite sample SH02. The middle two points are isotopic compositions of the mixture of garnet and bulk rock. The mixing proportion of garnet with whole rock and omphacite are 0.5 and 0.3 respectively.

We obtained a garnet-whole rock isochron age of 254 ± 16 Ma (2σ) for a Shanghe eclogite from the Dabie ultrahigh pressure metamorphic belt (see fig 1). The relative larger error is due to the low Lu concentration in garnet (1.1 $\mu\text{g/g}$) and close $^{176}\text{Lu}/^{177}\text{Hf}$ ratios in both garnet and bulk rocks (0.05 vs 0.01).

The result of Lu-Hf isochron represents the garnet formation age during continental subduction and late peak- and post- ultrahigh pressure (UHP) metamorphism didn't disturb the Lu-Hf isotopic system in garnet.

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Zircon and apatite fission track study on the mineralization of Nanliang gold deposit, eastern Hebei, China

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Xiayingfang gold ore district, Hebei province, China, occurs in Xinglong-Kuancheng arcuate fold area of Yanshan platform fold belt in eastern Yinshan-Yanshan EW tectonic belt. A granite-porphry intrusion, the principal part of magma activity in this area, is close related to the gold mineralizing process. This paper aims at studying the hydrothermal metallogenetic epoch and thermal history of Xiayingfang gold deposit, based on zircon and apatite fission track analyses for different alteration zones.

The zircon and apatite ages of six samples from ore and altered rocks range from 154 Ma to 120 Ma and from 114 Ma to 103 Ma respectively, indicating a about 22-50 Ma metallogenetic duration, and the metallogenetic time falls into early Yanshan epoch. The age data and quantitative AFT modelling show that there are two stages of gold mineralization, in which the first stage is of higher temperature and rapider cooling rate than the second stage and the time and temperature of the turning point between them is about 120 Ma and 100 °C. The first stage of mineralization resulted from intrusion of a granite-porphry body and took place in about 150 Ma, and second stage of the mineralization was related to both rhyolite-porphry and magma cryptoexplosive breccia and occurred in about 135 Ma. Combined with the mineralogenetic temperature of 370±290°C, 230±170°C and 150±80°C in vanward-, main- and late-mineralization period respectively, the ZFT and AFT ages correspond to the main- and late-mineralization period separately. Since the samples from different places are heated in different degree by the metallogenetic hydrothermal solution, the less the distance from the thermal source and the long the heating time is, the lower the measured fission track age. It is demonstrated that the quartz-sericitization alteration is earlier and lasts longer than the potassic alteration. Therefore, we consider fission track analysis of the minerals is useful to researching the metallogenetic epoch and thermal evolution history of hydrothermal deposits.

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The magnitude of ocean warming during the PETM: Implications for forcing and climate sensitivity

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The Paleocene-Eocene Thermal Maximum (PETM) provides a unique opportunity to observe the global climate sensitivity to a rapid and large increase in greenhouse carbon levels. Although the exact changes in atmospheric CO₂ levels have yet to be determined, carbon isotope and deep-sea carbonate accumulation records confirm the rapid (<10 k.y.) release of several thousand gigatons of carbon. Such a massive release over such a brief period should have raised pCO₂ by hundreds of ppm or more. In theory, global temperature should have increased, but with sea surface temperatures rising uniformly over most of the planet (i.e., in the absence of a strong ice albedo feedback). Such a response is supported by more than a dozen SST anomaly records from pelagic and shallow marine sections which show 5 to 9°C increase. Most of these SST anomaly records are based on oxygen isotopes data (from planktonic foraminifera) uncorrected for local salinity changes, and a few are based on Mg/Ca and TEX₈₆. In those few locations where multiple proxies are available, there is generally good agreement on the magnitude of SST change. The few exceptions are primarily in tropical pelagic cores where it appears the oxygen isotope based anomalies are damped. Reliable reconstructions of “absolute” SST, on the other hand, are far more limited since the low-mid latitude pelagic oxygen isotope records are compromised by diagenesis. Nevertheless, the few available records consistently show peak PETM temperatures well above modern, as high as 33°C in the mid-latitudes and 20 to 22°C in the Southern Ocean and Arctic. These SST estimates are extreme, and past attempts to simulate such high temperatures with CO₂ forcing alone required raising levels to extremes (>>3000 ppm). More recent studies demonstrate that elevated background levels of other trace gasses such as N₂O and CH₄, generated by biogeochemical feedbacks, may have amplified warming during the PETM. Given the potential implications for future warming, one of the major challenges facing the earth sciences community will be to improve the uncertainty in our estimates of SST for the PETM and other past episodes of transient global warming.

Mass transfer during volatile exsolution in magmatic systems: Insights from the analyses of silicate melt and magmatic fluid inclusions

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We analyzed silicate melt and primary magmatic fluid inclusions in numerous granitic systems and in the basaltic andesites of the Villarrica volcano to quantify the distribution of several elements between silicate melts and magmatic volatiles.

LA-ICPMS analyses of co-existing silicate melt and fluid inclusions, entrapped in miarolitic quartz crystals, allowed direct quantitative determination of fluid/melt partition coefficients. Investigations of various granitic systems (peralkaline to peraluminous in composition, $\log f_{O_2} = \text{NNO} - 1.7$ to $\text{NNO} + 4.5$) exsolving fluids with various chlorinities (1 to 13 mol/kg) allowed us to assess the effect of these variables on the fluid melt partition coefficients (D). Partition coefficients for Pb, Zn, Ag and Fe show a nearly linear increase with the chlorinity of the fluid ($D_{\text{Pb}} \sim 6 \cdot M_{\text{Cl}}$, $D_{\text{Zn}} \sim 8 \cdot M_{\text{Cl}}$, $D_{\text{Ag}} \sim 4 \cdot M_{\text{Cl}}$, $D_{\text{Fe}} \sim 1.5 \cdot M_{\text{Cl}}$, where M_{Cl} is the molinity of Cl). This suggests that these metals are primarily dissolved as Cl-complexes and neither oxygen fugacity nor the composition of the melt affects significantly their fluid/melt partitioning. Partition coefficients of Mo, As, Sb and Bi are highest into low salinity (1-2 mol/kg Cl) fluids with maximum values of $D_{\text{Mo}} \sim 20$, $D_{\text{As}} \sim 10$, $D_{\text{Sb}} \sim 8$, $D_{\text{Bi}} \sim 15$ indicating dissolution as non-chloride (eg., hydroxy) complexes. Fluid/melt partition coefficients of copper are highly variable, but highest between vapor like fluids and silicate melt ($D_{\text{Cu}} \leq 2700$), indicating important role of ligands other than Cl. Fluid/melt partition coefficients of Sn and W show a weak positive correlation with the chlorinity of the fluid ($D_{\text{Sn}} = 0.3 - 42$, $D_{\text{W}} = 0.8 - 60$), but likely decrease with decreasing oxygen fugacity or melt peraluminosity.

In situ quantitative determination of fluid/melt partition coefficients in mafic systems with the use of natural samples is limited due to the lack of well preserved fluid inclusions. However, very high excess concentrations of Cu and Ag have been analyzed in plagioclase-hosted silicate melt inclusions in basaltic andesites compared to those in co-genetic pyroxene and olivine (up to 4800 ppm Cu vs. 40-200 ppm Cu in plagioclase vs. pyroxene and olivine hosted melt inclusions). The excess Cu is due to heterogeneous entrapment of a high temperature (~1000 °C) vapor phase rich in Cu, Ag and S. This suggests that high-temperature magmatic vapors may play an essential role in the transport of Cu, Ag and S from mafic to felsic magmas in complex magmatic reservoirs.

Geochemical fractionation and anthropogenic metal pollution in sediments of Nakagawa River in Tokyo, Japan

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Nakagawa River sediments were collected from the whole river and analysed for heavy metals in the less than 63 µm grain size fraction. The geochemical fractionation of heavy metals was examined with a sequential extraction scheme and the concentration of iron, manganese, lithium, cobalt, cadmium, chromium, copper, nickel, lead and zinc were measured in the liquid extracts by flame atomic absorption and inductively coupled plasma mass spectrometry. A certified reference stream sediment sample (JSd-2) provided by the Geological Survey of Japan was also analysed using the same procedure as a check. The association of Cr and Pb with oxides and Zn with carbonatic and oxides were comparatively higher. Nakagawa River sediment was considered to be polluted on the basis of unpolluted sediments and geochemical background values with respect to Cr, Pb and Zn, which were several times higher than the limiting concentration where toxicological effects are expected. The geoaccumulation index for most of the sampling points also lies above zero indicating contamination in Nakagawa sediment for the aforesaid metals. The pollution could be linked to anthropogenic activities such as industrialization, urbanization, deposition of industrial wastes and others. A final evaluation of the Nakagawa River sediments heavy metal pollution will be made from the study results.

The evolution of μ and the isotopic composition of lead in the early solar system and young Earth

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A loss of volatile elements during the condensation of the solar nebula is the main fractionating process of CM, CO, CV and ordinary chondrites. These building blocks (constituting 85% of meteorite falls), from which the terrestrial planets accrete over the next 10-40 Ma, retain CI refractory element relative abundances but display deficiencies in their volatile elements correlating with condensation temperatures. As a consequence, these earliest condensates from the cooling solar nebula display, on average, an order of magnitude increase in μ ($m = {}^{238}\text{U}/{}^{204}\text{Pb}$) from ~ 0.1 to ~ 1 . Additional volatile element loss and further increase in μ continues to occur from impact melting on various scales throughout the accretion process. Differentiation of planetesimal bodies, such as metal-silicate separation, also produces chemical heterogeneity that may affect μ . Our best value for the bulk Earth μ comes from analyses of terrestrial Pb, which has evolved uniformly in isotopic composition over geologic time and provides an integrated μ value of ~ 9 for the crust and upper mantle. However, the possibility of other reservoirs in the core and lower mantle has hampered efforts to precisely determine the total bulk Earth μ value.

New and published meteorite data are presented to examine the effects of volatile element loss on U-Pb isotope systematics in the early solar system. Recent studies using the extinct Hf-W chronometer have shortened older estimates of the time between the origin of the solar system and the separation of the Earth's core. Accordingly, some proposed solutions to the Pb paradox—the positioning of both the Earth's crust and mantle to the right of the Geochron on Pb-Pb diagrams—that were based on a >50 Ma time span for Earth's accretion and core formation, are invalid. Allowing only 10-20 Ma for production and loss of radiogenic Pb before being retained by the Earth causes but minor rotation of a Geochron anchored to Canon Diablo initial Pb. Scenarios for the evolution of μ in the early solar system and young Earth, and comparisons with Mars, the Moon and other meteorite parent bodies will be given. It is concluded that the Pb paradox as well as the κ conundrum are due predominantly to long-term storage of radiogenic Pb in, and decoupled U, Th, and Pb transport among terrestrial reservoirs. In contrast, μ values are established at the time of planetary formation by the accretion of material that has suffered earlier and concurrent loss of volatile Pb, and can differ significantly among the terrestrial planets.

Relative and absolute timescales in metamorphism - Observations, calculations, estimations

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Presently there are several ways to record metamorphic processes through time. (i) In first order, metamorphic petrology is needed to set constraints on the relative record of metamorphic processes, and to provide information about the prograde and retrograde P-T evolution, and the metamorphic peak. Presently, detailed P-T paths can be reconstructed by comparison of information obtained from thin section observations (assemblage sequences, mineral zonations, mineral growth and resorption textures) and such gained by thermodynamic calculations, e.g. by using quantitative phase diagrams. (ii) Second, detailed petrographic observations are necessary to relate the evolution of rock forming minerals - used for P-T path reconstructions- to the evolution of accessory minerals commonly used for geochronology. In this context, trace element (TE) zonation patterns of rock-forming and accessory minerals can be useful. However, their application as thermometers and as “correlators” must be considered with caution, because their incorporation in accessory and rock forming minerals, as well as their distribution among minerals on a thin section scale is far from well understood. These problems can strongly influence the interpretation of P-T-t paths as well as dating results (e.g. Lu-Hf dating of metamorphic garnet). (iii) Dating of accessory and rock-forming minerals will provide evidence about the absolute timing of metamorphic processes, and the duration of orogenies. In addition it allows to discriminate between mono- and polymetamorphic evolutions, which cannot be distinguished unambiguously on the basis of structural and petrological data. Furthermore, the combined use of different dating techniques may allow to estimate cooling rates of metamorphic rocks, and our growing understanding between the evolution of accessory and rock-forming minerals to estimate the timing of prograde P-T paths. (iv) The use of T-t dependent processes, like mineral growth rates and diffusion rates, can set additional constraints on the timing of metamorphic processes. E.g. the knowledge of mineral growth rates may help to clarify the timing of prograde P-T histories, whereas diffusion rates can be used to model cooling rates of orogenic processes.

Finally, I should emphasize that only the combination of different techniques will lead us to a true understanding of the crustal evolution through time.

Zircon formation *versus* zircon alteration – New insights from combined U-Pb and Lu-Hf *in situ* LA-ICP-MS analyses, and consequences for the interpretation of Archean zircon from the Limpopo Belt

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We demonstrate that the combination of U-Pb and Lu-Hf isotope data obtained by LA-ICP-MS provides a powerful tool, which allows distinguishing zircon domains grown during several metamorphic-magmatic events from altered domains affected by complete single and/or multiple Pb-loss. This discrimination is possible, because the U-Pb and Lu-Hf isotope systems are decoupled during zircon alteration. We show that the initial $^{176}\text{Hf}/^{177}\text{Hf}$ ratio once “incorporated” into the zircon lattice remains nearly unaffected during later alteration processes which cause Pb loss. Newly formed zircon overgrowths always have higher initial $^{176}\text{Hf}/^{177}\text{Hf}$ than previously grown domains, due to the incorporation of additional radiogenic ^{176}Hf formed by ^{176}Lu decay in the rock’s matrix between the different zircon growth events. Such ^{176}Hf is not incorporated into zircon domains affected by post-growth alteration. By applying the U-Pb and Lu-Hf systems, in combination with cathodoluminescence (CL) imaging, we can show that zircon grains in the Sand River gneiss of the Limpopo Belt grew during three events; during magma crystallization at 3.28 Ga, a first anatexis at 2.64 Ga, and a second anatexis at 2.02 Ga. Our data also show that abundant zircon domains underwent multiple Pb loss, and that many of the 2.02 Ga old zircon domains result from complete Pb-loss of zircon domains already formed at 2.64 Ga. In contrast, all domains of complex zoned zircon grains from the Zanzibar granodiorite gneiss were formed during a single magmatic event at 2.61 Ga, but most of them suffered single and/or multiple Pb loss.

Recent bimodal eruptions from the Torfajökull-Veidivötn volcanic system, south-central Iceland: Insights into magmatic processes and their rates

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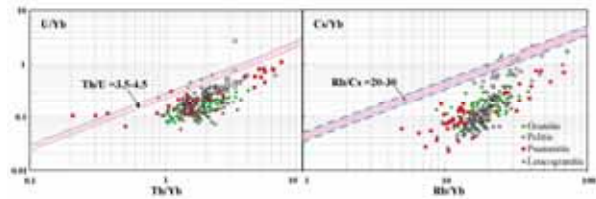
Historical bimodal composition eruptions spanning Torfajökull central volcano and neighbouring Veidivötn fissure swarm in southeastern Iceland were studied to examine the nature and timing of basalt and rhyolite petrogenesis at an active divergent plate boundary. Post-glacial eruptions in the area have sampled both tholeiitic and transitional alkali basalts as well as co-eruptive high-K rhyolites. Physical mixtures of these magmas were erupted at the boundary between these volcanoes, although this study focuses instead on lavas and tephra that most closely approach the mafic and felsic endmember magma compositions that fed the most recent eruptions in 871AD and 1477. Major and trace element data demonstrate that the samples sit near the ends of previously defined regional mixing trends. Whole rock and mineral U-Th-Ra-Sr isotopic compositions are consistent with both limited compositional variation in magma sources and relatively rapid petrogenetic timescales. Rhyolites display the greatest ^{230}Th excesses of up to 17%, yet have only slightly lower ($^{230}\text{Th}/^{232}\text{Th}$) activity ratios than coeruptive Veidivötn basalts. Both magma types display small but significant ^{226}Ra excesses, up to ~ 10% in the rhyolites and ~ 60% in the basalts. Trace element and isotopic data are consistent with crustal melting of a mafic source protolith of Holocene age to generate the 871 and 1477 rhyolites. The requirement for a young rhyolite protolith is inconsistent with previously suggested models involving old silicic segregation lenses or isostatically subsided source rocks to make Icelandic rhyolites. Mineral separates yield zero-age U-Th isochrons, and Ra-Th isochrons of a few kyrs, indicating that the crystals formed shortly prior to eruption, consistent with petrographic and mineral chemistry indicators that they are phenocrysts. We propose a model to explain the compositional similarity of west Torfajökull rhyolites with historically erupted rhyolites in which the former are produced by partial melting of transitional alkali basalts, while the latter are sourced from mafic protoliths that are chemically similar to the Veidivötn tholeiites but have suffered extensive K-metasomatism prior to melting.

Geochemical effects of deep subduction on the continental crustal materials

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Subduction of continental crustal materials to depths >100 km is well documented worldwide. However, how subduction affects the geochemistry of subducted continental materials is poorly understood. Deeply subducted (>100 km) sedimentary and granitic rocks from the Chinese Continental Scientific Drilling (CCSD) project are used to address such a critical question. Geochemical data on fresh pelitic, psammitic, and granitic rocks from 2800-3000 m and 4300-5000 m of CCSD main borehole show that (1) at similar SiO₂, Al₂O₃ and CaO, leucogranitic gneisses have the highest magnitude of variations in Rb/Sr and Rb/Cs ratios; (2) degrees of variation in Rb/Sr and Rb/Cs ratios appears to depend on K₂O; and (3) strong fractionation of Cs from Rb, and U from Th, resulting in highly elevated Rb/Cs (up to 400), and Th/U (up to 32) (Fig.). This can be explained by hydration induced K-feldspar to phengite transformation^[1] which preferential retain Rb over Sr and Cs that preferentially partition into a fluid. Pre-HP dehydration or HP-UHP hydration of continental materials also fractionates Th over U, which greatly increased the Th/U ratio of the hydrated continental materials, leaving lower Th/U ratios in the residue fluids. Zircons grown from such a fluid could have lower Th/U ratios, which is common in UHP metamorphic zircons^[2].



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Environmental vanadium distribution in soil in a V-Ti-Fe magnetite ore area, Panzhihua, south-west of China

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Vanadium (V) is a widely distributed trace element in the earth's crust. It had been confirmed that vanadium is an essential element for human and animals by the end of 1970's (Cantly, 1978) and has high or middle poisonous to animals when its bioaccumulation reaches to a certain degree. The transfer ability and bioaccumulation of V in surface environment depends on its concentration, as well as its speciation.

Panzhihua, located at the upstream of Yangtze River, P. R. China, has a world famous V-Ti-Fe magnetite ore. It is the biggest V-Ti-Fe ore in China, which occupies 64% of the total vanadium in China. The investigated soil is of Xigeda type.

In this paper, the distribution of total vanadium and its speciation in soil got from different depths (4 layers, 0-5 cm, 15-25 cm, 30-50 cm and 50-75 cm) in this famous V-Ti-Fe magnetite ore area has been studied. The contents of total vanadium and vanadium speciation were determined by sensitive catalytic oscillography.

The result show that the average content of vanadium in soil is 102 $\mu\text{g}\cdot\text{g}^{-1}$, which is much higher than the average value 86 $\mu\text{g}\cdot\text{g}^{-1}$ in China; the vanadium contents in soil samples came from mining area and smelting area are obviously higher than that from agricultural area and non-mining area. At the same sampling site, the content of vanadium is decreased by the increasing of sampling depth.

The sequential extraction analysis procedure of Tessier *et al* (1979) for heavy metals was used for the vanadium speciation separation. Although the main existing form of vanadium is residual form, the biological effect of vanadium in this area can be ignored. The summation content of exchangeable V and carbonate bound V, which can be directly bioaccumulated in natural conditions, is over 2 $\mu\text{g}\cdot\text{g}^{-1}$, while in most other research area is usually less than 1 $\mu\text{g}\cdot\text{g}^{-1}$. So the vanadium in this area has high transfer ability and high biological effect.

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The solubility of gold in H₂S vapor

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Although there is extensive evidence that magmatic vapors are capable of transporting high concentrations of some ore metals, modeling of the processes responsible for ore deposition is severely limited by the paucity of data on the solubility and speciation of metals in the vapour phase. As complexes with HS⁻ and H₂S are the principal forms of dissolved gold in aqueous liquids and H₂S partitions strongly into the vapor phase of hydrothermal systems, it is likely that gaseous H₂S is important in promoting the volatile transport of gold. In this paper, we report the results of the first of a series of experimental studies designed to investigate the solubility of gold in H₂S-bearing water vapor.

This first study examines the solubility of gold wire in H₂S gas. The experiments were conducted in titanium alloy autoclaves at 300 to 400°C and pressures up to 230 bars. The total pressure was assumed to be equal to the pressure of H₂S gas and was calculated from the PVT properties of this gas. The redox potential was controlled by the S/H₂S pair. At the end of an experiment, the autoclaves were quenched and Au condensed on the walls of the vessel was dissolved in aqua regia. The solubility of Au in H₂S gas was calculated from its concentration in this acid. The results of our experiments indicate that the solubility of Au in H₂S increases with both temperature and *f*H₂S, reaching a concentration of 95 ppb at 400°C. Based on the *f*H₂S dependency, we propose that the species controlling the solubility of Au in H₂S gas has the form AuS·(H₂S)_{*n*} or AuHS·(H₂S)_{*n*} with a solvation number between 1 and 2 at 300-400°C. The equilibrium constants for the reactions controlling formation of these two species are *log K* = -11.1 ± 0.2 at 300°C (both species), -10.7 ± 0.3 and -10.5 ± 0.3 at 350°C, and -10.6 ± 0.2 and -10.4 ± 0.2 at 400°C, respectively.

Results of this study and preliminary experiments in the Au-H₂S-H₂O system, which yielded even higher Au solubilities, provide evidence that H₂S may play a major role in dissolving Au in hydrothermal vapor, something which may be key to understanding the genesis of porphyry and epithermal gold deposits.

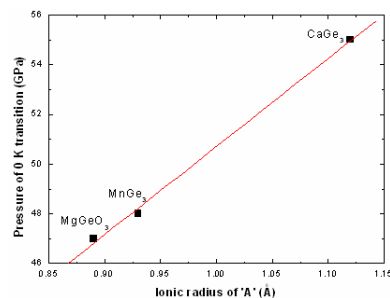
Influence of 'A' cation ionic-radius on the structure and bulk modulus of ABO₃ perovskite and postperovskite

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Recently, high-pressure experiments and theoretical calculations demonstrate that (Mg,Fe)SiO₃ postperovskite is the predominant mineral in the lowermost mantle called the D'' layer, and phase transition from perovskite (Pv) to postperovskite (PPv) has significant geophysical implications for the nature of the D'' layer (Hirose 2006). The available experimental data of bulk modulus and 0 K transition pressure from Pv to PPv were investigated for ABO₃ perovskite and postperovskite, it was found that a linear relationships between the radius of 'A' cation and bulk modulus exists in ABO₃ Pv and PPv. The bulk modulus decreased linearly with increasing the radius of 'A' cation. On the other hand, there is also a positive linear relation between the 'A' cation ionic radius and the 0 K transition pressure for germinates perovskite, which indicates the transition pressure increasing linearly with the increasing the radius of 'A' cation, so the transformation into postperovskite phase becomes more difficult with the large ionic radii of 'A' cation in ABO₃ perovskite (see Fig.). As the phase transitions from Pv to PPv is due to the distortion of BO₆ octahedra in Pv, our results suggest that the ionic radius of 'A' cation probably play an very important role on the structure and the phase transformation of ABO₃ compounds.



Acknowledgments

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Environmental geochemistry in relation to agriculture and human health in Hainan Island, China

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As the biggest island in tropical China, Hainan Island possesses advantageous hydrothermal conditions, high biodiversity and soil diversity.

The environmental geochemistry of this area is determined mainly by the special geological background and pedo-geochemical processes, which are characterized by the diversified lithology and tropical soil formation processes.

One major problem is the high Al toxicity of soils of the island. Total and exchangeable aluminum of soils in different weathering stages are high as compared to that of parent materials. About a half of the studied soils contain exchangeable aluminum higher than the threshold value of causing hazard to plant. Soils developed from basalt in the north part of the Island have the highest aluminum content while that from marine deposit lowest.

Agricultural production, including tropical cash crop cultivation, is affected soil acidity and acidification. Rubber cultivation has an accelerated acidification. Rice and upland crops also changed the acidity of soils of the Island.

Calcium is severely deficient in soils, surface water and plant. One nutritional problem is the intake of Ca of local people from their daily diet is much lower than that of nation-average as well as that of subtropical region.

It is suggested that based on the understanding of the environmental geochemistry problems, we are able to adjust agricultural structure in the way of interfering the cycling of some important plant nutrients for improving agricultural production and human health in this tropical Island.

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Dynamic reactivity of metals in soils – Relevance to uptake by plants

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To predict the availability of metals to biota, it is necessary to understand both solution and solid phase supply processes in the environment. The kinetics of metal release from particles and complexes can limit the rate of uptake of metals. Complex dissociation rates in solution can be measured by several approaches. The rate of release of metal ions from particles in soils and sediments has been difficult to assess directly. The technique of DGT (diffusive gradients in thin-films) had been used to measure dissociation kinetics in solution and release from solid phase in soils. DGT perturbs the equilibrium system by lowering the local concentration of metals and measuring their supply. By modelling the dynamics of the DGT-soil system, kinetic information, such as the rate constant of supply from the solid phase and the labile pool size of metals, can be obtained.

Measurements have been performed in several metal soil systems. The results show that the rates of Zn and Cd supply are generally faster than those of Ni for the same soil. Relative slow rates of supply for Ni are consistent with general understanding of its kinetics of release from complexes. In clay soils the rate of release of Zn and Cd are generally too fast to measure, but measurable rates can be observed in some sandy soils. The rate of supply of Zn in freshly spiked soils is higher than in historically contaminated soils, indicating that the aging effect relates to the kinetics of resupply and cannot be solely attributed to a fraction of Zn being rendered unavailable. The rate of As release from solid phase to solution in the rhizosphere was much slower than that in the bulk soil. These kinetic findings are relevant to the uptake of metals by plants because DGT emulates the prime effect of the plant on soil, namely removal of metals.

To assess the metal dynamics in soils in relation to uptake by plants, we have used the measured Michaelis-Menten parameters of plants to predict the fluxes of metal that they remove from a given soil. The fluxes were comparable to the fluxes measured by DGT, showing that plants and DGT perturb the metal chemistry of the soil to similar extents. The soil kinetic parameters measured by DGT which influence the metal uptake by the device, will therefore also exert a control on the metal uptake by plants.

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Structural and geochronological studies of the Fuping Complex: New constraints on the tectonic evolution of the Trans-North China Orogen

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The Trans-North China Orogen (TNCO) is interpreted as the site where two discrete continental blocks, called the Eastern and Western Blocks, amalgamated to form the coherent basement of the North China Craton in the late Paleoproterozoic^[1-2], but its deformational history and timing have not been well constrained. In this study, we present structural and SHRIMP zircon data for the Fuping Complex, one of the largest complexes in the TNCO. Detailed mapping and structural investigations reveal that the Fuping Complex experienced four distinct deformational episodes (D₁ to D₄). The D₁ is characterized by isoclinal tight fold (F₁), penetrative F₁ fold axial planar foliation (S₁) and mineral lineation (L₁). Earliest L₁ displays a preferred NW-SE orientation with a shallow plunging angle, indicating the earliest direction of collision. The D₂ is the major deformation episode in the complex, represented by ubiquitous E to SE-verging isoclinal, overturned -to- recumbent folds (F₂) of varying scales, F₂ fold axial planar foliation (S₂) and crenulation lineation (L₂). Both D₁ and D₂ deformations corresponded for the prograde metamorphism (M₁). The extensional D₃ generated regional-scale NW (W)-SE (E) trending upright open folds (F₃) that warped the whole complex into dome and basin patterns. The last D₄ is characterized by brittle fabrics and low-angle detachments, which are related to the complete exhumation of the complex. Both D₃ and D₄ corresponded for the decompression (M₂) and retrograde (M₃) metamorphism, respectively.

SHRIMP U-Th-Pb zircon ages from leucocratic dykes reveal that pre-D₁ leucocratic dykes were emplaced at 2484±13 Ma, whereas zircons from syn-D₂ folded leucocratic dykes yield SHRIMP zircon ages of 1843±12 Ma and 1844±18 Ma, respectively. Zircons from post-D₂ leucocratic dykes give SHRIMP zircon age of 1817±14 Ma, older than published zircon ages of 1790±8 Ma and 1799±9 Ma for post-tectonic undeformed granitic pegmatite dykes. Structural and SHRIMP U-Th-Pb zircon data indicate that the Fuping Complex, together with adjacent Wutai and Hengshan Complexes, underwent uniform deformational histories incorporated into an eastwards subduction during final assembly of the North China Craton at ~1.85 Ga.

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FTIR features of coals from the Ordos Basin (NW China): Implications on hydrocarbons from coal

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The Ordos Basin, located in NW China, is typical of accumulation of multi energy resources including oil, gas and coal. We have performed the study on some coal samples with variable maturation from brown coal to anthracite by Fourier Transform Infrared (FTIR) Spectroscopy analyses. The goal is to have a deeper understanding of the evolution of hydrocarbons from coal. The method of curve-fitting analysis was used in order to more precisely quantify peak areas of different coal structure. Despite of the fact that the studied samples are not along a natural series due to different bio-precursors, they may also imply the ability and evolution of hydrocarbon generation of coals. Analytical results indicate that variation of IR spectra corresponds to the stage of hydrocarbon generation relatively well.

Firstly, when vitrinite reflectivity (Ro) of the samples is below 0.6%, IR spectra area around 1705 cm⁻¹ which represents stretching vibration of oxygenous groups in coal descends fastly with the maturation increasing. This implies that a lot of hydroxyl group and methoxyl group break off from coal and become carbon dioxide to migrate. IR spectra area of 2950 cm⁻¹ and 2920 cm⁻¹ represents asymmetric stretching vibration of methyl and methylene, respectively. However, we did not observe a clear change of these two function groups. In this stage, only a few amounts of oil and gas were generated based on thermal simulation experiment of brown coal.

Secondly, when Ro of the samples reaches 1.3%, FTIR spectra area around 1705 cm⁻¹ decreases to zero. Meanwhile, IR spectra area of 2950 cm⁻¹ and 2920 cm⁻¹ diminish continuously, which means plenty of aliphatic group and aliphatic ring break off to becoming oil and gas. The ratio of methyl (CH₃) to methylene (CH₂) representing the length of aliphatic chains of coal and a branching index increases. This may be ascribed to the break of long aliphatic chains and the conversion of hydroaromatic methylene structures to aromatic rings during hydrocarbon generation. A large amount of oil and gas have been generated through the thermal simulation experiment, and the coal almost reaches the hydrocarbon generation peak in this stage.

Thirdly, when Ro exceeds 1.3%, IR spectra area of 2950 cm⁻¹ and 2920 cm⁻¹ disappear, and the process of hydrocarbon generation from coal stopped. The CH₃/CH₂ ratio does not represent the length of aliphatic chains here. In summary, abundance of hydrogen and oxygen in coal decreases and carbon concentrates along with the coal rank increasing and hydrocarbon generative maturation.

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A general kinetic model of plagioclase dissolution

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Feldspar dissolution is of great geochemical interest and has been intensively studied in the laboratory. The plagioclase solid-solution series provides a unique candidate for fundamental investigations of feldspar dissolution. Factors that affect dissolution kinetics of a particular plagioclase composition include saturation state, pH, ionic strength, organic ligands and temperature. Feldspars consist of a tectosilicate framework where variation in the distribution of Al and Si generate order/disorder phenomena. In the entire plagioclase feldspar solid solution series, the Al content increases from endmembers albite (Na[AlSi₃O₈]) to anorthite (Ca[Al₂Si₂O₈]). These factors have significant influence on the dissolution kinetics and are potential indicators of dissolution mechanism.

We use a stochastic model to study plagioclase dissolution. The model incorporates bond-breaking, bond-forming, surface diffusion, detachment and attachment of various Si- and Al- ions and complexes to and from solution. The resulting dissolution is the outcome of the stochastic treatment designed to explore the kinetic behavior of a many-body process. The model involves the full crystal structure, highlighting the essential correlation of dynamics of neighboring sites on the surface.

We examined eight different plagioclase compositions, representing the entire solid solution series. Our results indicate that “unlimited deepening” into the bulk structure by leaching of Al yields a consistent log-linear dependence of dissolution rate on anorthite content. Only when the dissolution process is confined to the top several surface layers, the transitional point (about An₇₀) can be successfully generated. At this point rates accelerate rapidly, and log(rate) departs positively from its linear relationship with An. In the case of (Al, Si) disorder, unlimited leaching of Al results in a 5-fold increase in dissolution rate from low albite to totally disordered high albite. In contrast, (Al, Si) disorder had no discernible effect on reaction mechanism involving the top layers. Subsequent modeling results on ΔG dependence, aluminum inhibition and surface chemistry are all comparable with previous experimental data in the framework of top-layer reaction mechanism. This confirms (1) feldspar dissolution under acidic conditions is a surface-controlled process, (2) surface processes modify the uppermost unit cells by leaching of Al, and (3) a thick layer of precipitates is generated on top of the leached interface.

Partial melting during the exhumation of the UHP rocks in Dabieshan Massif

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The partial melting associated with or induced by decompression during the exhumation of the UHP rocks is one of the most important physicochemical processes postdating the collision event in an orogen. The strongly deformed foliated granite (orthogneiss) and associated felsic or pegmatitic granite pods and veinlets are widespread in the UHP and HP units in Dabieshan massif, which can be interpreted as the result of decompressional partial melting of the UHP rocks in the mid-lower crust under amphibolite facies conditions. The granitic and felsic pods or veinlets are clearly intrusive, as they contain deformed enclaves of eclogite, retrograded eclogite and country rock gneiss, and the contact in some cases is cross-cutting. In some localities where larger UHP eclogite bodies occur, there is a gradual transition, from eclogite → amphibolized eclogite → eclogitic amphibolite → amphibolite (frequently with symplectites of plagioclase + amphibole) → (garnet bearing-) biotite hornblende plagioclase gneiss (so called UHP rocks) → (garnet bearing-) foliated granite. The REE distribution patterns of the UHP rocks suggest a common type of protolith. The foliated granite has the geochemical characteristics of A-type granite and formed in the post-COLG environment. The geochemical features and Pb-Sr-Nd isotope tracing indicate that its magma source is related to the UHP rocks.

Most of the partial melting phenomena are concentrated in the fractures within the eclogite, retrograded eclogite and their country rocks, which supports that the partial melting must be happened during the decompressive retrogression of the eclogite to amphibolite facies and the uplift of eclogite to lower-middle crustal level. The large-scale migmatites (metatexites) and the foliated granite (anatectite) of the UHP/HP terrane in the Dabie massif are important geologic records of partial melting and the transfer of the thermal state in the crust. It is also an important physicochemical process in decreasing the competence, enhancing the deformability of the rocks and stimulating the transformation from the compressional regime to the extensional regime.

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Dissolution morphology as an indicator of respiration mechanism in *S. oneidensis*

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The mechanisms and kinetics of dissimilatory iron respiration by bacteria are important to a variety of globally significant environmental processes. As a tool to examine iron respiration, the dissolution of iron (oxy)(hydr)oxide particulate coated glass slides under a variety of conditions was observed with atomic force microscopy (AFM). It was found that the dissolution morphology of the particulates in the presence of wild-type *S. oneidensis* MR-1 is heterogeneous (Figure 1), whereas an abiological chemical reductant, 9,10-anthrahydroquinone-2,6-disulfonate (AH₂DS, oxidized form of AQDS), dissolves the coatings homogeneously. The behaviour of a gspD deletion mutant (deficient in solid-iron mineral respiration) respiring via an exogenous electron shuttle, AQDS, was also examined. The resulting dissolution morphology was homogeneous, similar to the abiotic experiments using AH₂DS. These results suggest that the kinetics of respiration of wild-type *S. oneidensis* MR-1 may be in part controlled by transport, whereas, the action of chemical reductants are primarily limited by surface processes. It is likely that wild-type organisms respire on iron (oxy)(hydr)oxides using a different reduction pathway(s) or kinetic regime(s) from AH₂DS and may explain the difficulty in comparing the kinetics of bacterial respiration to a chemical reductant.

Figure 1: Heterogeneous dissolution of iron oxyhydroxide particulates exposed to wild type *S. oneidensis* MR-1 for one day. Image size is 85 μ m and Z-scale is 436.32 nm.



Zircon U-Pb age and Hf isotope evidence for growth and reworking of the Yangtze continental nucleus

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To understand the connection between continental cratonization and global tectonothermal event is essential for recognizing the formation and evolution of continental crust. For this purpose, a combined study of zircon U-Pb and Hf-O isotopes was conducted on migmatite, gneiss and metapelite from the Kongling complex (the only Archean microcontinent outcropped in South China) and the Liantuo sandstone in Yichang. The results show great significance for growth and reworking of Yangtze continental nucleus. A detrital zircon as old as 3.8 Ga was revealed by SHRIMP U-Pb dating for the Liantuo sandstone of middle Neoproterozoic age, implying the existence of crustal materials with this age in the Yangtze Block. Its Hf isotopes suggest growth of juvenile crust at 4.0 Ga. Zircon U-Pb ages for the migmatite and gneiss from the Kongling complex suggest two episodes of magmatism at 3.2-3.3 Ga and 2.9-3.0 Ga, probably marking formation of Yangtze continental nucleus at Mesoproterozoic. Their Hf isotopes suggest extraction of mafic protolith from the depleted mantle no later than 3.5 Ga ago.

U-Pb ages of 1.97 ± 0.03 Ga were obtained with low Th/U ratios of 0.01 to 0.14 for metasediments and amphibolite from the Kongling complex, indicating that the ages are a record of Paleoproterozoic metamorphic event. $\epsilon_{\text{Hf}}(t)$ values of about -6.5 and model Hf ages of about 3.0 Ga were acquired for zircons from the metapelites, suggesting an Archean source. Thus a response to the Paleoproterozoic global tectonothermal event in South China is reworking of Archean continental nucleus. A survey of Paleoproterozoic ages throughout the Yangtze Block suggests that metamorphic event and subsequent magmatic activity occurred in the north, but only magmatic activity in the south. Both metamorphic and magmatic activities are associated with formation of a unified basement responsible for cratonization of the Yangtze Block. This provides a geodynamic connection between the formation of this craton and the global tectonomagmatism in the Paleoproterozoic, marking continental accretion by arc-continent collision orogeny during assembly of the supercontinent Columbia.

A number of Neoproterozoic U-Pb ages were also dated in detrital and metamorphic zircons, consistent with those widely occurring in the periphery of the Yangtze Block. This period of tectonothermal events is associated with contemporaneous rift magmatism in response to the Rodinia breakup. It results in not only remelting of Archean and Paleoproterozoic arc-derived crust but also prompt reworking of Neoproterozoic juvenile crust. Therefore, the growth of continental crust in the Yangtze Block started since the early Archean, but a stable craton through reworking did not occur until the Paleoproterozoic.

Controlling mechanism of thermochemical sulfate reduction

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Thermochemical sulfate reduction (TSR) is the reaction to form H_2S , which not only can critically affect the economic value of hydrocarbon gas, but is highly toxic and corrosive for production equipment. However, the exact nature and reaction mechanisms which influence the TSR are not known. In present study elemental sulfur and different sulfates are applied to investigate hydrocarbon reduction in different aqueous. Our result suggests that the nature of the aqueous is critical for TSR reactions and products. Aqueous with elemental sulfur can trigger the reaction quickly and complete the reaction within short time, but gas products dominated by H_2S and CO_2 with minor amount of hydrocarbon gas (<5%) clearly contradict those natural gases from most TSR areas. Acid salt aqueous phase formed by strong acid and weak base (Ca, Mg) seems facilitate TSR, and produces gases dominated by hydrocarbons with well situated amount of H_2S (0~25%). However, aqueous with alkali metal (Na, K) sulfate is hard to trigger TSR reaction because of the neutral pH of salt aqueous phase by strong acid and strong base. Therefore, slightly acidic medium with abundance SO_4^{2-} should be the prerequisite for initiating TSR at carbonate reservoirs. Therefore, the likelihood and intensity of TSR can be predicted on the base of concentrations of four type of anions (Cl^- , SO_4^{2-} , CO_3^{2-} , HCO_3^-) and two type of cations (alkali metal ions such as Na^+ , K^+ and alkaline earth metal ions such Ca^{2+} , Mg^{2+}) in formation water. This result is compatible with our case study in the Sichuan Basin where the aqueous within TSR occurrence area contains high concentration of SO_4^{2-} ion and alkaline earth metal ions (Ca^{2+} , Mg^{2+}) with low concentration of CO_3^{2-} and HCO_3^- ions.

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Mantle metasomatism in the peridotite xenolith from Panshishan, Jiangsu Province, China

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Panshishan alkaline basalt is located in the joint area of Jiangsu and Anhui Provinces. It is a Cenozoic volcanic cluster (N_1^3) of Luhe-Yizheng in the SE seaboard of China. The alkaline basalt contains a lot of spinel lherzolite xenoliths. Detailed electron-microprobe study revealed that substantial mantle metasomatism taken placed, and many metasomatic mineral phases related to mantle melt/fluid occur in the intergranular spaces of primary ones.

Detailed observation revealed that the course-grained metasomatic Cr-diopsides develop between the primary olivine grains, and a primary Cr-spinel is found in it. A lot of fine-grained Cr-spinels develop in the Cr-diopside, which exsolved from the Cr-diopside. At the joint position of the Cr-spinel and Cr-diopside a kind of silicate glasses develops, rich in Si, Al and K and poor in Fe and Mg, which are believed to be derivatives of the metasomatic process of mantle fluid. And between the Cr-diopside and the primary olivine a spong-rim develop, which consists of feldspar + silicate glasses (Fe-,Mg-rich, Si-,Al-,K-poor and volatile-rich) + olivine + apatite + Cr-spinel. It is suggested that the upper mantle rock could have been at least undergone two periods of mantle metasomatism in the area. First period of metasomatism formed the mineral assemble of feldspar + olivine + apatite + Cr-spinel + Cr-diopside, which could be related to a melt/liquid with higher viscosity; And the second period of metasomatism formed the silicate glasses rich in Fe and Mg and depleted in Si and Al, which might indicate a melt/liquid with lower viscosity. The Metasomatic phenomenon can account well for that the mantle source of the alkaline basalt had been undergone enrichment process during Neocene.

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Lithogenic inputs over the Kerguelen Plateau (Southern Ocean) traced by the dissolved REE concentrations and Nd isotopic composition

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The Southern Ocean is regarded as a key region in understanding the role of biogeochemical cycling on the variation of global climate (Marinov *et al.* 2006). Although this Ocean is characterized by HNLC conditions, areas of high biomass do occur including the Kerguelen plateau. These bloom occurrences are attributed to natural fertilisation due to iron inputs from the Kerguelen archipelago and plateau (Blain, Treguer *et al.* 2001). The major goal of the KEOPS project was to study the result of this natural iron fertilization, and in particular to identify its sources.

REE are an extremely coherent group in terms of chemical behavior (Elderfield and Greaves 1982). Seawater Nd isotopic composition is a tracer of water mass pathways and of their interactions with continental material. Although the oceanic cycles and sinks of dissolved Fe and REE are different, the dissolution of lithogenic material constitutes the main source for both dissolved Fe and REE in the ocean. Therefore, we propose to use REE concentrations and Nd isotopic compositions in the Kerguelen Plateau waters to 1) trace the origin of the observed iron enrichment and 2) quantify the fluxes of the lithogenic inputs.

We will present dissolved seawater REE concentrations and Nd isotopic compositions from 9 stations upstream from and above the Kerguelen plateau. The REE patterns display positive Eu anomalies in the water masses above the plateau, which are similar to those of the Kerguelen basalts, suggesting that the high dissolved REE contents observed in the waters above the plateau result from the dissolution of lithogenic material, such as from Kerguelen or Heard Islands. Lithogenic fluxes were estimated larger than 110 ± 21 ton Nd y^{-1} , and 37000 ton Fe y^{-1} , for dissolved Nd and Fe, respectively. The under processing Nd isotopic composition analyses will allow a better understanding of the dissolved/particulate exchange occurs at Kerguelen Plateau/water masses boundaries and also allow to quantify this exchange.

Spherical diffusion couple, closure of core composition, and geospeedometry

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In dealing with diffusion in minerals, a spherical diffusion couple is often encountered. Examples include diffusion between the core and mantle (or two concentric layers) of garnet, or spinel, or zircon. This problem does not seem to have been solved analytically before. I present an analytical solution for a spherical diffusion couple. The concentration evolution is shown in Figure 1 and differs from the one-dimensional diffusion couple in a couple of ways. One is that the mid-concentration position (or interface) moves to the shell with smaller radius as a function of time. Nonetheless, a spherical diffusion couple may be fit well by an error function: diffusivity obtained from such a fit is only slightly different from the actual diffusivity, but the interface position is noticeably away from the original interface. Therefore, the original boundary between two layers is not at the position of mid-concentration. The solution is applied to derive the closure conditions for the center of the core, which is compared with the numerical solution for the specific case of oxygen diffusion in zircon (Watson and Cherniak, 1997). Furthermore, given a measured concentration profile, if it can be shown that it is due to diffusion (not growth), the mean diffusion distance may be obtained, from which the cooling rate may be inferred.

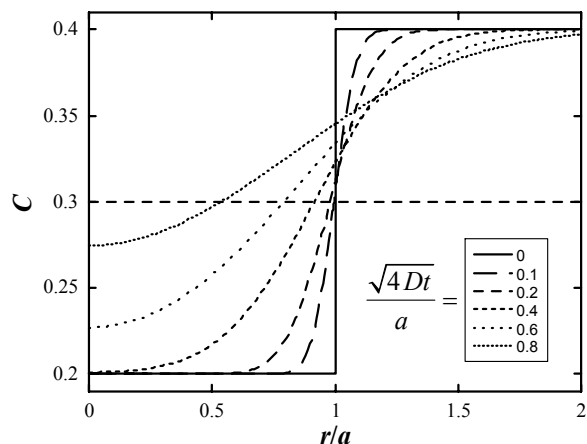


Figure 1. Concentration evolution for a spherical diffusion couple, where C is concentration, r is the radial coordinate, a is the radius of the initial core, D is the diffusivity and t is time.

Preliminary studies on Sr/Ca and Mg/Ca ratios in aragonitic marine bivalve shells by ICP-OES, ICP-MS and LA-ICP-MS

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The trace element composition of marine biogenic carbonates is gaining increased attention as a proxy for past climates and environments. We have employed ICP-OES, ICP-MS, and LA-ICP-MS to determine the trace element ratios of the shells of *Arctica islandica*. We evaluated the applicability of these three instruments and explored the characteristics of Mg:Ca and Sr:Ca ratios.

The sample material was life-collected from different localities around Iceland. Each shell was sampled in youth, mature and gerontic life stages (umbo, middle part, tip). The results are as follows: 1) Sr:Ca ratios: ICP-OES data are similar to the ICP-MS results; LA-ICP-MS data for middle portions are same as ICP-OES values; 2) Mg:Ca ratios: LA-ICP-MS results of umbonal and middle shell portions are lower than corresponding ICP-OES results, but the data from tip parts are slightly higher; And ICP-OES results are higher than corresponding the ICP-MS results, this findings coincides with previous findings by Andreasen *et al* (2006);

For a better interpretation of the results, we used EMPA to analyze the spatial distribution of Sr and Mg in cross-sections of the specimens. According to these element distribution maps, Mg is less homogeneously than Sr. In many portions of the annual increment, the Mg concentration is very low and Sr high. These data suggest that Mg and Sr ions behave totally different in aragonitic shells than in calcitic skeletons. The Mg content may be related to the organic matrix, while Sr may be more related to the carbonate matrix. This may be the reason for the difference in the three analyses.

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He and Ar isotopic composition of pyrite and its significance in XZ uranium ore-field, South China

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XZ uranium ore-field was one of the most important granite-type uranium deposits in China. Many argues such as mefeoric, magma ann mantle derived fluid on the original of the ore-forming fluid. Isotopic composition of He and Ar in pyrite, one of the most important paragenetic minerals with pitchblende in XZ uranium ore-field been applied to reveal the original of the ore-forming fluid in this paper. Pyrite paragenetic with pitchblende was sampled from the mine galley. He and Ar isotope was analyzed by the MI-12011G inert gases mass spectrograph. Calculated results shown in table 1 and the results discussed below:

Table 1. He and Ar isotope composition of Pyrite

No	³ He/ ⁴ He (×10 ⁻⁷)	⁴ He(×10 ⁻⁶) cm ³ STP/g	⁴ He*(×10 ⁻⁶) m ³ STP/g	Rc/Ra
1	10.66±0.80	10.15	0.22	0.79
2	2.08±0.17	62.65	0.22	0.15
3	0.76±0.15	62.87	0.22	0.055
4	1.36±0.30	59.15	0.22	0.098

NB : Ra=1.39×10⁻⁶ ; radiogenic origin ⁴He* correct formula
⁴He* = 0.2355×10⁻⁶×U* cm³/MgH₂O, U*
 =U[1+0.123(Th/U) - 4] , suppose U=150×10⁻⁶

³He/⁴He value varied in 0.79~0.06Ra, higher than 0.01~0.05Ra, the crust ³He/⁴He value, but lower than 6~7Ra, the continental mantle ³He/⁴He value^[1]. All samples distributed between the crust original and the mantle original range in ³He/⁴He diagram, which suggests that it had the crust and mantled mixed original of the ore-forming fluid. ⁴⁰Ar/³⁶Ar value varied between 282~319, all samples distributed between the crust original and the mantle original range in Rc/Ra vs. ⁴⁰Ar/ ⁴He diagram, which also suggest the characteristic of mixed Ar original. The isotopic composition of He and Ar in pyrite might suggest that ore-forming fluid of XZ uranium ore-field might be the mixed product of crust and mantle fluid.

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Geochemical constraints on the petrogenesis of Devonian arc picrites and associated lavas from the North Junggar terrane, NW China

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The Junggar terrane in Xinjiang Province, sits adjacent to the Siberian and Kazakhstan plates. Recently, we recognized a near 100-m-thick picritic lava flow in a Devonian arc in Junggar terrain. The picritic lavas, which occur in the lower part of the Middle Devonian strata, are overlain by basalts and andesites. The picrites are highly porphyritic. Olivine, clinopyroxene and rare chrome spinel with $Cr\#$ ($Cr/(Cr+Al)$) values (0.63–0.86) are phenocrysts, embedded in a matrix of groundmass plagioclase, clinopyroxene, and Ti-magnetite. Glass does not appear to be preserved, but minor metal sulfides are present. All lavas are characterized by negative Nb, Ta and Ti anomalies with similar abundances of HFSE with MORB, exhibiting typical for island arc volcanic rocks. The Zr/Nb ratios (23–66) of the picrites and basalts resemble the MORBs (10–66), suggesting the MORB-like sources. However, the Ti/V (23–35) and Zr/Sm (18–23) ratios of basalts are higher than those of picrites (14–17 and 14–15 respectively), and the basalts display flat-type REE-chondrite patterns whereas the picrites are characterized by lower total REE concentrations and slight enrichment of light REE. In contrast, the andesites have much higher total REE abundances and LREE/HREE. All suggest that they are not cogenetic related. However, they have similar ($^{87}Sr/^{86}Sr$)_t (0.70328–0.70433) and $\epsilon_{Nd}(t)$ values (6.4–7.3), overlapping with modern island arc field. Consequently, primary magmas were most likely generated in N-MORB-type mantle, which was modified by the addition of a fluid component derived from subducted basaltic crust. However, the basalts were generated by partial melting of amphibole-bearing spinel peridotite, and the picrites resulted from low degrees of partial melting of garnet peridotite with residual garnet, and the andesites may have been generated by partial melting of eclogites.

Continental paleotemperature reconstructions: Distribution of GDGTs in a variety of lakes

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In spite of the rising tide of using the TEX86 index in the reconstruction of marine sea surface temperature, applications to lake environments are still limited, with only a few large lakes surveyed. Calibrations of modern environmental conditions with surface sediment Tex86 temperatures in smaller lakes are lacking or not apparent in many settings. We have collected surface sediments from a variety of lakes extending from the Arctic, to southern Patagonia and northern Chile. These include Norwegian cirque lakes, a maar lake in Patagonia, Argentina, a meteorite impact crater lake in Siberia, and a glaciated valley lake in England. In each case, we collected a suite of measurements of the physical parameters of the lake, such as temperature, salinity, pH, etc, in order to determine how the modern distribution of GDGTs correspond to the current environmental conditions across a large range of limnologic conditions. Preliminary results indicate the temperatures calculated from the TEX86 index are consistent with the measured annually averaged surface water temperature, although complications related to soil-derived sources are apparent in some cases. A complete set of data and selected downcore reconstructions of late Holocene conditions will be reported at the conference.

Molecular level simulations of the H₂O, CO₂ and CO₂-H₂O systems up to high temperatures and pressures

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H₂O, CO₂ and CO₂-H₂O are the most frequently encountered fluid systems in and around the Earth, widely existent in various geospheres, as revealed from direct measurements or from the study of fluid inclusions in various rocks and ore deposits. In this study, we have carried out a series of molecular dynamics and Monte Carlo simulations to predict the properties of these systems up to high temperatures and pressures, which are difficult or even impossible to attain with experimental measurements.

For pure water, we selected a potential model (SPCE) established at normal temperature and pressure and found remarkable reproducibility of molecular dynamics simulations over wide temperature and pressure ranges. Compared with the most recent published high-pressure experimental data up to 5.0 GPa, the simulation results show very good agreement with errors less than 1.0% and reveal a trend to be more accurate as the increase of pressures.

For carbon dioxide, we have proposed an optimized potential model utilizing the established techniques of molecular dynamics and histogram reweighting grand canonical Monte Carlo simulations. This model is demonstrated to show excellent predictability for thermodynamic, transport, and liquid structural properties in a wide temperature-pressure range with remarkable accuracies.

Thereafter, through comprehensive isothermal-isobaric molecular dynamics simulations, the pressure-volume-temperature-component (*PVTx*) data of CO₂-H₂O have been extended beyond experimental range (below 1673.15 K, 1.94 GPa) to about 2573.15 K and 10 GPa.

Finally, an equation of state (EOS) was laboriously developed for the H₂O, CO₂ and CO₂-H₂O systems. This EOS reproduces all the experimental and simulated data covering a wide temperature and pressure range from 673.15 to 2573.15 K and from 0 to 10.0 GPa within experimental or simulation uncertainty.

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Diagenetic environment of Qingbulake basic complex, Xinjiang, NW China

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The Qingbulake basic complex is located 120km southeast to the Tekesi County, Xinjiang, NW China. As the Sm-Nd age is similar to the Karatunk complex in the south margin of Altay orogenic belt and Huangshandong complex in eastern Tianshan, these intrusions were considered to be formed in the similar post-collisional environment.

In this study, the high precise SHRIMP zircon U-Pb age of 434±6.2 Ma for diorite from the complex reveal that the major mafic magmatic events took place in the early to middle Silurian. According to recent research on the regional tectonic evolution (e.g., Li *et al.*, 2006, Gao *et al.*, 2006), at least in early Silurian, the southern Tianshan oceanic crust began the subduction to central Tianshan plate and ended in early Carboniferous. Geochemical studies of the Qingbulake basic complex show that it is characterized by low content of Ti, depletion of Nb and Ta and enrichment of large lithophile elements and slight enrichment of LREE. The magma also displays some features of inland arc magma (Zhang *et al.*, 2006).

So the Qingbulake mafic complex may be closely related to the subduction of southern Tianshan ocean crust to Yili-Central Tianshan plate.

Acknowledgement

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The Trans-North China Orogen – A long-lived arc: Evidence from SHRIMP U-Pb zircon ages of granitoid gneisses in the Lüliang Complex

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The Lüliang Complex is situated in the central segment of the Trans-North China Orogen (TNCO), a continent-continent collisional belt along which the discrete Eastern and Western Blocks amalgamated to form the basement of the North China Craton [1-5]. The complex consists of supracrustal and granitoid gneisses, of which the latter can be subdivided into the Yunzhongshan TTG gneisses, Guojiazhuang granitic gneisses and Chijianling-Guandishan granitoid gneisses. These granitoid gneisses are mostly calc-alkaline and considered to have formed in a magmatic arc environment. SHRIMP U-Pb analyses reveal that the Yunzhongshan TTG gneisses were emplaced at $\sim 2499 \pm 9$ Ma, representing the earliest arc-related magmatic event in the Lüliang Complex. This was followed by the intrusion of the Guojiazhuang granitic gneisses at 2375 ± 10 Ma. The most widespread arc-related magmatic event in the region was the emplacement of the Chijianling-Guandishan granitoid gneisses at 2199-2173 Ma, respectively. Metamorphic zircon overgrowth rims from a tonalitic gneiss yielded a weighted mean $^{207}\text{Pb}/^{206}\text{Pb}$ age of 1872 ± 7 Ma, consistent with the metamorphic age range of 1880-1820 Ma defined by metamorphic zircons from various high-grade rocks in the TNCO. Thus, the evolution of the Lüliang Complex involved emplacement of the Yunzhongshan TTG suite at ~ 2499 Ma, the Guojiazhuang granites at ~ 2375 Ma and the Chijianling-Guandishan granitoids at 2199-2173 Ma, with the final collision between the Eastern and Western Blocks in this area occurring at 1872 ± 7 Ma, the whole series of magmatic events lasting nearly 650 Ma. This suggests that the Trans-North China Orogen represents a long-lived magmatic arc. This study was financially supported by the Hong Kong CERG grants (7055/05P, 7058/04P, and 7063/06P) and a Chinese NSFC Grant (40429001).

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Crustal architecture of the Dabie orogen: Constraints from U-Pb age, Hf and O isotopes in zircon from UHP granitic gneiss

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Zircon U-Pb dating, Hf and O isotope analyses were carried out for granitic gneiss from North Dabie, the largest lithotectonic unit of ultrahigh-pressure (UHP) metamorphic rocks in the Dabie orogen, east-central China. The results are used to provide not only insight into its protolith origin and metamorphic history with respect to continental subduction, but also constraints on crustal architecture prior to and after collision. Zircon U-Pb dating gives consistent ages of 751 ± 7 Ma for protolith crystallization, and two group ages of 213 ± 4 to 245 ± 17 Ma and 126 ± 4 to 131 ± 36 Ma for metamorphism. Most of zircon Hf isotope analyses show negative $\epsilon_{\text{Hf}}(t)$ values of -5.1 to -2.9 with crust Hf model ages of 1.84 to 1.99 Ga, suggesting that their protolith was originally derived from reworking of Paleoproterozoic crust. The remaining analyses from one sample exhibit strongly positive $\epsilon_{\text{Hf}}(t)$ values of 10.6 ± 0.8 ; some of them have the highest values of 12.4 to 14.5, corresponding to the youngest Hf model ages of 743 to 827 Ma relative to the depleted mantle. Thus, gneiss protolith was derived from reworking of the Paleoproterozoic crust due to rift magmatism in response to the Rodinia breakup at about 750 Ma. This differs from bimodal protolith of the classic Central Dabie UHP metamorphic zone, which has zircon Hf isotope features indicating prompt reworking of Neoproterozoic juvenile crust. Oxygen isotope analysis yields zircon $\delta^{18}\text{O}$ values of -3.26 to 2.79% , which are considerably lower than those of the normal mantle. This suggests differential involvement of meteoric water in protolith magma by remelting of hydrothermally altered low $\delta^{18}\text{O}$ rocks. It appears that North Dabie shares the same ages of Neoproterozoic low $\delta^{18}\text{O}$ protolith and Triassic UHP metamorphism with Central Dabie, but it was significantly reworked at Early Cretaceous. The Rodinia breakup at about 750 Ma would lead to not only growth of juvenile crust in an active rift zone for bimodal protolith of Central Dabie, but also reworking of Paleoproterozoic crust in an arc-continent collision zone for the North Dabie protolith. The difference in the occurrence of Cretaceous ages between North Dabie and Central Dabie suggests that the two UHP metamorphic units were not located on the same level during the Cretaceous magma emplacement, but a lower level for North Dabie. This also provides a constraint on the source depth of Cretaceous granitoids, which was probably deeper than the North Dabie gneiss.

Artificial radionuclides recorded in lacustrine sediments in Bosten and Qinghai Lakes, NW China

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Establishing accurate historical records of the distribution, inventory and source of artificial radionuclides in the environment are important for environmental monitoring and radiological health protection due to its high toxicity, and useful for identification and risk assessment of possible future environmental inputs of radionuclides from nuclear weapons test and from the accidental release from the nuclear fuel reprocessing process and the power plant reactor. It has been known that the ²³⁹Pu/²⁴⁰Pu atom ratio is a good indicator to identify the source of Pu because this isotope ratio is characteristic for various Pu sources. On the other hand, accurate dating of lake sediments is important for many studies, such as the reconstruction of pollution history of organic pollutants and heavy metals, historical variation of biological productivity and carbon preservation, and early diagenetic processes in the sediments. Taking into account the long half-lives of Pu isotopes this technique established could be a useful tool for next researchers to study the history of anthropogenic pollutants in the environment.

We applied a sector-field ICP-MS to study the recent sedimentation in ca. 10 lakes in China via measurements of both Pu and U isotopes, besides the conventional radiometric determination of ²¹⁰Pb and ¹³⁷Cs. In this work, we report the results of Lake Bosten and Qinghai in the Northwestern China. The Pu activity profile obtained with SF-ICP-MS was in agreement with a γ spectrometric ¹³⁷Cs profile, indicating that the ¹³⁷Cs and Pu activities convey essentially the same information about sedimentation processes in the investigated lakes. Based on the isotopic compositions of Pu and U isotopes, the sources of artificial radionuclides and the potential application of Pu isotopes for sediment dating will be discussed.

The Re-Os systematics of the Bixiling eclogites, Dabieshan, central China

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The Bixiling ultrahigh pressure (UHP) mafic massif, located in the North Dabie high-T/UHP granulite-facies zone, Dabieshan, central China, is one of the largest and most extensively studied outcrops of eclogite-facies rocks in the world [1]. This massif was involved in Triassic subduction and subsequent exhumation of the Yangtze craton beneath the North China craton, as is well recorded by garnet-omphacite Sm-Nd isochrones [2]. However, the ages of possible older metamorphic events and of protolith formation are still debated, which adds uncertainty to the geodynamic models of the Dabie-Sulu orogenic belt.

Here we present preliminary Re-Os results of 15 eclogites and 2 granite gneisses collected near the eastern edge of the Bixiling massif (N:30°43', E:116°17'). Os and Re were extracted using Carius tube digestion + bromine extraction + micro-distillation/anion exchange techniques and analyzed by NTIMS (Os) or by ICPMS (Re). Non-radiogenic Os concentrations are extremely low (<1 pg/g) in all eclogites except DB42 (386 pg/g). This is consistent with the formation of the massif by fractional crystallization of a roughly cogenetic magma in a crustal intrusion. DB42 is thought to represent a basal norite cumulate, which stripped Os from the overlying magma as it formed. Re concentrations vary from 51 pg/g to 2835 pg/g. With the exception of a ratio of 0.1565 for DB42, ¹⁸⁷Os/¹⁸⁸Os ratios vary from 8 to 390. These high ratios are mainly due to the very low non-radiogenic Os contents. Except for one sample (BXL-3, with 2835 pg/g Re), all Re-Os data yield unreasonably old T_{MA} ages, implying significant Re loss, most likely during subduction-exhumation. If a 750 Ma protolith age is assumed, 20%-60% Re loss is calculated, which is similar to that inferred for subduction of oceanic crust [3,4]. On the other hand, Sm-Nd results from garnets suggest that the Bixiling protolith formed less than 300 Ma before subduction [2]. Our Re-Os results are consistent with only the oldest limit of this estimate; younger ages would require a protolith with an unreasonably high Re concentration. Analysis of mineral separates prepared from BXL-3 indicates that garnet and omphacite host only a small fraction of the total Re in this sample. An additional phase (sulfide?) is required to explain the missing Re.

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Relationship between Hg and sulfur in coal from Huaibei coalfield, China

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Many authors have reported that Hg in coal can exist in solid solution within pyrite. Correlations between sulfur and Hg are often attributed to this mode of occurrence and are most common in coals that are extremely enriched in Hg.

The result of this study shows that coal samples from the Huaibei coalfield have relatively low sulfur values (average 0.59%). The correlation coefficient between ash and sulfur is -0.08, indicating that sulfur in the Huaibei coals has an intermediate (organic and inorganic) affinity. In a study of 29 coal samples from the Huaibei coalfield, We observed that organic sulfur is the dominant sulfur form when the total sulfur is near 0.5%. Some literatures report that organic sulfur compounds can capture Hg and result in the enrichment of Hg in coals.

The conclusion shows the relationship between Hg and sulfur in all 29 coal samples that we examined; note that the correlation coefficient is only 0.17 (n=29). Interestingly, and it shows a significant positive correlation between Hg and sulfur (n=21, R=0.64, p<0.05) is obtained by excluding the eight samples from the No. 5 and 7 coal seams, which were influenced by a magmatic intrusion. This suggests that the magmatic intrusion not only increased the concentration of Hg in seams 5 and 7, but also changed the mode of Hg occurrence in these seams. The significant, positive correlation between Hg and sulfur in coals from the No. 3, 4, and 10 seams suggests that Hg in these coal seams is bound to both organic sulfur moieties and within sulfide minerals.

Rb-Sr isochron age of gold-rich quartz veins in the Lingqueshan gold deposit, Shandong Province in China

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Mineralogenetic matter, mineralogenetic liquid, and mineralogenetic age are three core problems in mineral deposit Research. Among them mineralogenetic age is a important aspect in mineral deposit research. To ascertain the mineralogenetic age of a mineral deposit has significance in ascertain the relation between the mineralogenetic function, regional tectonics function, metamorphic function and magma function, and has significance in research of mineralogenetic matter, mineralogenetic liquid, and mineralogenetic cause of formation. Now direct determination to the mineralogenetic age method mainly are K-Ar method, Ar-Ar method, fluid inclusion Rb-Sr isochrone method, Sm-Nd method, Pb-Pb method, and so on. Since in 80th in 20 century the method of fluid inclusion Rb-Sr isochrone was used in mineralogenetic age research, many domestic and overseas scholars did attempts in this aspect, and some scholar put forward some oppugn with the lack and dependability of this method. The paper has determined the Rb-Sr isochron age of Gold-rich quartz veins in the Lingqueshan gold deposit, and discusse the mineralogenetic age.

The Zhao-Ping fracture zone is the master gold metallogenic zone in China, but the study on the gold deposit lays in the hanging wall of the Zhao-Ping fracture zone is very rudimental. The Lingqueshan gold deposit lays in the hanging wall. In order to know the timing of the gold deposition, so the Rb-Sr isochron dating methods have been adopted to date deposit, the result indicates that the age of the Lingqueshan gold deposit is 118±9.4Ma. It is consistency with the age of Jiaodong gold deposits concentration zone (120±10Ma). That is to say, the large-scale metallogeny of the Zhao-Ping fault zone hanging wall took place in early cretaceous occurred in north western Jiaodong Peninsula.

Zircon U-Pb age, Hf and O isotope insight into origin of Neoproterozoic granitoids in South China

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The genetic links between rift magmatism, crustal growth and reworking, and granitoid petrogenesis are an important issue with respect to supercontinent breakup. A combined study of U-Pb age, Hf and O isotopes in zircons from Neoproterozoic granitoids in South China, including the Jiangnan orogen between the Yangtze and Cathaysia Cratons, the Kangdian rift along the western margin of the Yangtze Craton, and the Dabie-Sulu orogen along the northern margin of the Yangtze Craton. Two generations of magma crystallization are discerned for the granitoids, with double-bimodal features in their zircon Hf and O isotope compositions. Despite consistently high $\delta^{18}\text{O}$ values of 8.1 to 10.4‰ for zircons, ~825 Ma S-type granitoids in the Jiangnan orogen show not only positive $\varepsilon_{\text{Hf}}(t)$ values of 3.4 to 5.4 with young Hf model ages of 1.17 to 1.25 Ga, but also negative $\varepsilon_{\text{Hf}}(t)$ values of -3.4 to -1.6 with old model Hf ages of 1.81 to 1.92 Ga. In contrast, 760-750 Ma bimodal I-type intrusives in the Kangdian rift are characterized by positive $\varepsilon_{\text{Hf}}(t)$ values of 3.5 to 9.9 with young model Hf ages of 0.94 to 1.18 Ga, and by both low and high $\delta^{18}\text{O}$ values of 4.2 to 6.2‰ relative to $5.3 \pm 0.3\%$ for normal mantle zircons. Bimodal protoliths of 780-750 Ma ages for metaigneous rocks in the Dabie-Sulu orogen have consistently low $\delta^{18}\text{O}$ values of -4.3 to 4.4‰ for igneous zircons, but their Hf isotopes are subdivided into two groups: one has positive $\varepsilon_{\text{Hf}}(t)$ values of 5.9 to 12.9 and young Hf model ages of 0.82 to 1.24 Ga, and the other has neutral $\varepsilon_{\text{Hf}}(t)$ values of -2.7 to 2.3 and old Hf model ages of 1.68 to 1.92 Ga.

The zircon Hf-O isotope systematics provides a link of granitoid petrogenesis to orogenic collapse, rift magmatism, water-rock interaction, and the Rodinia breakup. Growth and reworking of juvenile and ancient crusts are dated by means of zircon $\varepsilon_{\text{Hf}}(t)$ values and model Hf ages in combination with U-Pb ages. While a change in magma source from arc-derived crust to asthenospheric mantle keeps pace with the tectonic advance from supercontinental rifting to breakup, reworking of pre-existing arc-continent collision orogen in either successful or failed rifts plays a basic role on their composition. As a result, the granitoids have principally inherited their source features in element and isotope geochemistry, with additional changes due to partial melting, fractional crystallization or crustal contamination. A plate-rift model is thus proposed to resolve paradoxical interpretations concerning trace element and isotope patterns of both arc-like and rift-like sources in given suites. It also provides a resolution to the controversy between arc-derived and plume-related magmatism for the Neoproterozoic igneous rocks in South China.

Re-Os systematics of lithospheric peridotites from Nushan, east China: Implications for multiple modifications of SCLM

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The Nushan Quaternary volcanic cone in northeast Anhui province, carries abundant mantle xenoliths which including spinel and garnet phase peridotites with or without volatile-bearing minerals such as amphibole, phlogopite and apatite. 12 representative xenoliths were selected for determination of Re and Os concentrations and Os isotope compositions.

Os and Re abundances range from 0.876 to 2.417 ppb and from 0.019 to 0.306 ppb respectively, while $^{187}\text{Os}/^{188}\text{Os}$ and $^{187}\text{Re}/^{188}\text{Os}$ ratios vary from 0.1149 to 0.1310 and from 0.037 to 0.805 respectively in this sample set. 4 of 12 samples have Os concentrations of <1.0ppb. Such low Os concentrations have usually been attributed to S-undersaturated melt percolation that remove Os-bearing sulfides. 2 of 3 fertile garnet lherzolites with high equilibration temperatures (~1100°C) have the highest $^{187}\text{Os}/^{188}\text{Os}$ ratios, similar to the present value of PUM (~0.1296). All spinel lherzolites from fertile to refractory in major chemical compositions, with or without amphibole and/or phlogopite have unradiogenic $^{187}\text{Os}/^{188}\text{Os}$ ratios. 6 of 12 samples have $^{187}\text{Re}/^{188}\text{Os}$ ratios higher than the PUM ratio of 0.435 that indicating recent Re addition. Nushan mantle xenoliths define a well-correlated linear trend between $^{187}\text{Os}/^{188}\text{Os}$ and both Al_2O_3 and Yb, through the PUM composition and give the model age of primitive melt extraction event (~2.0Ga).

Previous data indicate that $^{143}\text{Nd}/^{144}\text{Nd}$ and $^{87}\text{Sr}/^{86}\text{Sr}$ isotope ratios of clinopyroxenes separated from the sample set fall on the mantle array in the depleted quadrant. It is interesting that $^{187}\text{Os}/^{188}\text{Os}$ and $^{143}\text{Nd}/^{144}\text{Nd}$ ratios have a linear positive correlation for the sample set. The sample with the most depleted $^{187}\text{Os}/^{188}\text{Os}$ ratio has the richest $^{143}\text{Nd}/^{144}\text{Nd}$ ratio and 2 garnet lherzolites with the highest $^{187}\text{Os}/^{188}\text{Os}$ ratio have rather depleted $^{143}\text{Nd}/^{144}\text{Nd}$ ratios. The decoupling of Os and Nd isotope compositions of the Nushan mantle xenoliths indicate that SCLM experienced complex multiple modification via modal and/or cryptical mantle metasomatism after primitive melt extraction.

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Fluid phase separation from residual intercumulus alumosilicate liquid of the Merensky Reef

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Fluid inclusions in both symplectitic and mirolitic quartz of the Merensky Reef of the Bushveld Complex (South Africa) have been studied using cryometry, microthermometry, Raman-spectroscopy, LA ICP-MS, scanning electronic microscopy, gas-chromatography and isotopic methods. This allowed us to obtain principally new information about an order of fluid phase separation from the Merensky Reef crystallizing intercumulus liquid.

We attempted to document at least three generations of fluid separated from boiling residual alumosilicate intercumulus liquid in the following sequence.

The earliest fluid phase composed of homogenous high dense gas mixture (from CH₄-98.48 and N₂-1.52 to CH₄-73.21, CO₂-24.42 and N₂-2.37 mol.%) was identified in primary gas and co-existing anomalous (combined) fluid inclusions from mirolitic quartz.

The next generation was heterophase fluid, composed of brines or water-salt solution, containing a free low dense gas phase (CO₂>N₂). This fluid was observed in primary multiphase and coexisting gas-rich inclusions from interior zones of mirolitic quartz crystals.

The latest generation was also heterophase fluid (low salinity water-salt solution and free low dense gas phase) that was found in primary water-salt and syngenetic CH₄-rich gas inclusions from peripheral zones of mirolitic quartz crystals.

The results give us a possibility to suggest that magmatogene fluids that successively separated from alumosilicate liquid changed from homogenous high dense gas phase to immiscible heterophase oxidized mixture during the crystallization evolution of the Merensky Reef.

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Different forms of sulphur in the Lower Cambrian Ni-Mo mineralized black shale in Zunyi, Guizhou Province, southwest China

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A great and famous Ni-Mo polymetallic deposits are developed in the Lower Cambrian Niutitang Formation in South China. As these mineral deposits are all sulfide, we measured different forms of sulfur in the outcrop Zhuliushui section, Zunyi (SW China) and have a preliminary analyses on their distribution.

Analytical results indicate that along the section, in wallrocks around deposits, the sulfur-content is less than 1%; whereas at the deposit seam (ca. 20-cm-thick) the content exceeds 1%, even high up to 23.807%. This implies that the formation of mineral deposits is closely related to sulfur. In order to know what roles do different kinds of sulfur play, three forms of sulfur including sulphate, pyrite sulfur and organic sulfur were further investigated. It is showed that the content of sulphate is mostly lower than 1.0%, while the other two forms ranging from 0.0441-6.233 (pyrite sulfur) and 0.0192-16.822 (organic sulfur), respectively. This likely implies that the sulfur in the mineralization comes relatively low from sulphate and great from pyrite. Furthermore, under microscopic observation, most of the pyrites occur in the formation of crystal granule, which may be ascribed to slow and successive sedimentation during the early diagenesis.

Otherwise, there is not a good relation between the organic and pyrite sulfurs, as the variation of the former was greater than the latter. Thus, it is suggested that the organic sulfur was also not the key factor in the process of pyrite's formation. In a word, based on the above analyses, we tentatively suggested that both hydrothermal fluid and surfur produced by biodegradation were responsible for the mineralization here.

Lastly and interestingly, besides the high sulfur content in the presently known Ni-Mo mineralized deposits, we also found another sulfur-peak in the upper 10-cm-thick seam, which located about 5 m on the above. Whether this is an indicative of another mineral deposit needs a more comprehensive investigation in the future.

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Climatic and environmental glaciochemical records from a climatic interaction region, East Antarctica over the past 780 years (1215-1996 AD)

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An 82.5-meter ice core was retrieved from marginal area of Dome A, East Antarctica by Chinese Antarctic Scientific Research Expedition in 1998/1999. Previous research shows that the area belongs to a continental-oceanic climatic interaction region.

Based on the ion chromatography analysis, we present the glaciochemical characteristics of the ice core in Antarctica over the past 780 years (1215-1996AD). Our results show that the climatic and environmental variability during 780 years in this area can be divided into three stages as follows:

Stage I is from 1215 to 1460AD, with a gradual decrease of the local annual snow accumulation rate and concentrations of most major ions.

Stage II is from 1460 to 1800AD, reaching the lowest accumulation rate and representing strong cooling. Concentrations of the major cations of Na⁺, Mg²⁺ and the anion of Cl⁻ in sea salt reduce distinctly, with the maximum drop in NO₃⁻ and MSA, indicating the possibility to trace environmental changes by chemical ions. This period coincides with the Little Ice Age in Northern Hemisphere.

Since 1800, Stage III is characterized by a rapid increase of the annual accumulation and concentrations of the major cations and anions, implying the increase of local temperature, which is consistent with the global warming after the Industry Evolution.

It seems that in Antarctica, the global climatic and environmental variability is recorded in the climatic interaction region rather better than in the other regions.

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Mantle fluids involved in metallogenesis of the gold deposits in the hanging wall of Zhao-ping fault: Evidence of H-O isotopes

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The Jiaodong region is located on the eastern margin of the North China Craton and the western Circum-Pacific tectonic belt. It is bounded by the Wulian-Rongcheng fault and the Dabie-Sulu ultrahigh-pressure metamorphic belt in the southeast and the Tanlu fault in the west.

The Jiaodong region is the large cluster of gold mineralization in China. Zhao-Ye gold zone is one of the major gold mineralization zones in Jiaodong. There is many large and medium-sized gold deposits, such as Linglong gold deposit, Dayingezhuang gold deposit and Xiadian gold deposit et. But most of this gold deposits are located under Zhao-Ye gold zone. The gold deposits are located in the hanging wall of the Zhao-Ye gold zone have little people to study except Sun Zhongshi (Jilin University). At present, Lingqueshan gold deposit located in the hanging wall of the Zhao-Ye gold zone have put into production. It is advantage for studying on the material sources.

Fluids are distillation of Ore-forming, which origin, movement and matter uninstal reflect the whole process of ore forming. The composing of Ore-forming fluids is an important parameter to demonstrating geochemistry character of Ore-forming. The paper study on the geochemistry character of H-O isotopic of gold deposit located in the hanging wall of Zhao-Ye gold zone, in order to discussing the origin of fluids of ore forming.

Zhao-Ye gold zone is one of the major gold mineralization zones in Jiaodong. The gold deposits located in the hanging wall of the Zhao-Ye gold zone have little people to study, which occurs mainly in the Jiaodong rock group. The ores are mainly of the auriferous quartz vein type hosted in NE trending fractures and faults. Wall-rock alterations are most potassic alteration, siliconization, quartz-sericitization, pyritization and carbonatization. According to research of geological characteristics of deposit and analysis of fluid inclusion of quartz. The $\delta^{18}O$ value of the quartz vein ranges from 4.78‰ to 10.12‰, and the average value is 6.22‰. The δD_{H_2O} values of inclusion fluid vary from -73.13‰ to -100.15‰, and the average value is -86.63‰. The research shows that this area mineralogenetic heat fluid is mainly curtain fountain, and participated in a certain degree of magma water and atmosphere water, has the same mineralogenetic heat fluid system with the other Zhao-ye gold deposit.

Effects of cave environmental condition on drip-water hydrogeochemical characteristics

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Speleothems contain large amount information of earth paleoenvironment change. Multi-proxies, supported by a series of hypothesis, have been used to interpret paleoenvironment change of karst. However, the records of speleothems are seldom coincident within the same cave and contradictive results have been reported. To clarify high resolution, short time scale information urged to reduce noise. Understanding hydrogeochemical processes happening in cave roof can contribute to interpret paleoenvironment change. Cave systems were monitored in Jiangjun Cave in Anshun county of Guizhou province, China, lasted for a year. NaCl was adopted to trace sources of cave drip water, time scales of drip water responding to precipitation, and processes of water dynamics in the cave. 4 drip points were monitored. The result shows that time scale of drip-water responding to rainfall was very quick (0-9 days). Drip water chemical components were directly originated from soil and greatly affected by the soil thickness. The thinner soil was; the less substances water dissolved. Water passed more quickly, which decreased the possibility of dilution happening in drip water, simultaneously, increased the contribution of rock to drip compositions. Different sources of water affected drip water dynamic process, which led to piston flow for JJD-1#, and increased drip ratio and water head pressure for JJD-2# as well while water was of much quantity. The process of rock dissolution and calcite precipitation mainly controlled elements variations of 4 drip waters while water transported in the route and acted with soil and rock. Consequently, as an important karst environmental factor, soil decides and controls drip compositions of cave drip waters, which means more attentions must be paid to soil in future study.

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Tracing natural CO₂ geological sequestration processes with noble gases

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Isotopic and elemental fractionation of noble gases can be used, together with other gases, to identify and quantify the origin, migration and sequestration processes of natural CO₂ gas deposits. The Jackson Dome CO₂ reservoir lies north east of the Jackson Dome intrusive in Mississippi, USA. The reservoir occurs between 4270m and 5180m depth and is assumed to have formed by thermal decarbonation reactions associated with the Jackson dome intrusive contact with related carbonate formations. 10 gas samples were collected and analysed for both noble gases and major gas composition. CO₂ ranges from 98.75% to 99.38%. Trace amounts of CH₄ and N₂ are correlated, and both correlate negatively to CO₂, suggesting that CH₄ and N₂ have a different source to that of the CO₂. The highest concentrations of N₂ and CH₄ are found on the crest of the trapping structure.

³He/⁴He ratios range between 4.27R_a and 5.01R_a (where R_a is the atmospheric value of 1.4×10⁶), indicating a strong mantle signature. CO₂/³He ratios vary between 1.07×10⁹ and 4.62×10⁹ and are in the range of the values found in pure magmatic samples (1-7×10⁹). The source of the CO₂ is not due to thermal decomposition of carbonates, but is dominated by magmatic gas.

The relationship among major gases (CO₂ and N₂), ⁴⁰Ar, ⁴He and Ne isotopes shows that the gases in Jackson Dome reservoir are a mixture of a fractionated air component, a magmatic end member and a radiogenic/crustal component. ²⁰Ne can be crudely used as a groundwater proxy. Anti-correlation of ²⁰Ne with CO₂/³He shows that groundwater plays a role in CO₂ sequestration and may be responsible for more than 70% of CO₂ loss. This is a common feature seen in other magmatic CO₂ rich natural gas fields (Gilfillan *et al.*, 2007)

²⁰Ne/³⁶Ar in the gas phase is higher than the groundwater ratio of ~0.16 with values of 0.798 to 1.35. CO₂/³He ratios correlate with both ²⁰Ne/³⁶Ar and δ¹³C (CO₂) values. We explore a variety of models to explain this data including: oil-groundwater partitioning; gas-groundwater partitioning; excess air dissolution and noble gas re-dissolution. A solubility controlled Rayleigh fractionation of groundwater modified by oil interaction appears to account for all correlations.

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Redefining feldspar-water interfaces

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Currently prevailing theory or hypothesis on kinetics is that feldspar dissolution is controlled by surface reactions. However, recent atomic scale electron microscopy studies of naturally weathered K-feldspars in the Navajo sandstone, Arizona (Zhu *et al.*, 2006), labradorite dissolved in pH 1 solutions in the laboratory at room temperature (Hellmann *et al.*, 2003), and alkali-feldspars dissolved at 200 °C and 300 bars (our unpublished) show that there is an amorphous layer on the dissolving feldspar surfaces. Furthermore, K-feldspars from the Navajo sandstone show tightly adhered coating of kaolinite and a 3-5 micron thick smectite (Zhu *et al.*, 2006). We believe the amorphous layer and secondary coating layers are important characteristics that bear significances on the feldspar dissolution kinetics. We advance two hypotheses for explaining the field-lab discrepancy. First, the secondary minerals rinding on feldspars are not at local equilibrium with groundwater, as traditionally assumed, but their slower precipitation rates can raise the groundwater saturation state with respect to feldspars to very close to equilibrium, and thus retard the feldspar dissolution rates. Feldspar dissolution reaction in aquifers is within a complex web of reactions, in which secondary clay precipitation plays a key role. Second, a thin (~ 10 nm) amorphous layer, possibly leached in origin, is found on feldspars that we examined. The presence of the amorphous layer on naturally weathered feldspars requires re-consideration of the details of surface reaction controlled mechanism.

Stable sulfur isotopic composition of H₂S and its TSR origin in Sichuan basin, China

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The natural gas has widely some H₂S in Sichuan basin; the contents are from minim to 18.6 percents. The high H₂S-bearing natural gas lies in the Feixianguan Formation, Leikoupo Formation and Jialingjiang Formation of Triassic; the Sinian, Carboniferous and Permian reservoir have lower contents H₂S, Xujiache Formation of Triassic and Jurassic have micro or free sulfur in natural gas reservoir. The research shows that the gypsiferous rock of Feixianguan Formation, Leikoupo Formation and Jialingjiang Formation of Triassic, Sinian and Carboniferous reservoirs provide the physical matter for TSR; the Permian lower H₂S-bearing natural gas is mainly from the pyrolysis of organic sulfur source rock. The stable isotopic composition of sulfur show that the sulfur isotope of H₂S-bearing gas has a short at 7~11‰ of the reservoirs sulfate, and that the sulfur isotopes of lower H₂S-bearing have widely distributing and about 15‰ short of most data. The stable isotopes of sulfur have a wide distribution extent and step change in the gypsiferous rock of Triassic, which are similar to the H₂S in the distributed law (Fig.1), the data indicate that the sulfur comes from the sulfate in the H₂S and TSR occurs in the respective reservoirs. Otherwise, the temperature conditions are similar as the TSR occurs, which means that the H₂S generates in the similar temperature condition and the fractional process of sulfur isotopes have no concern with the sulfur isotopes of sulfate, the temperature and extent of reaction are the key factors in the TSR process.

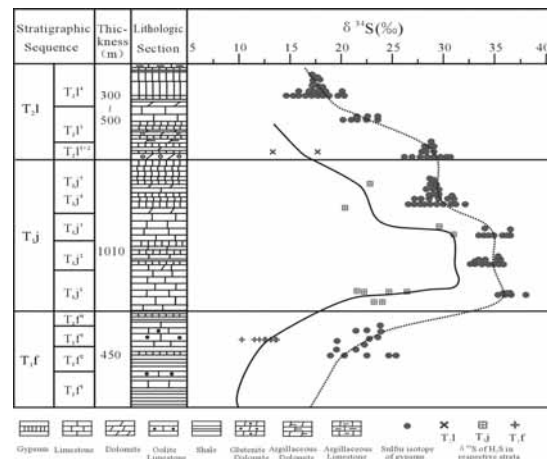


Fig 1. $\delta^{34}\text{S}$ of H₂S and gypsum of Sichuan basin

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Investigation on the origin of Se-rich soils and selenosis in Yutangba, China

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Yutangba was known as a typical high-selenium (Se) area in China where a sudden incidence of human Se poisoning occurred in 1963. The surface exposed Se-rich carbonaceous cherts and carbonaceous shales (locally known as stone coal) of the Permian Maokou and Wujiaping formations at north part of Yutangba were generally considered as the major source of Se that was enriched soils in Yutangba and other places in Enshi Prefecture. However, little study has been conducted to confirm the source of Se in soils of Yutangba, and the causes of the sudden incidence of human Se poisoning was still in debate so far (Zhu *et al.* 2004).

161 soil samples were collected from the entire Yutangba area. Abnormal Se content was observed in 11 soil samples with Se concentrations ranging from 346 to 2018mg/kg with an average of 899±548 mg/kg. Selenium fractionation was investigated in 3 of them based on the sequential extraction protocol described by Kulp *et al.* (2004), which showed that elemental Se extracted by 1mol/L Na₂SO₃ was the predominant fraction (>90%) while other fractions are a few percent. These abnormal soil samples were further studied using SEM with EDX for elemental Se. Native Se crystals were discovered and they were surprisingly well preserved mainly as cubic-prismatic in form and more than 20µm in size (ground soil powder). These morphological characteristics are very similar to that of reported native Se crystals derived from natural burning of stone coal on the subsurface of abandoned stone coal spoils, but significantly different from the elemental Se formed by bacterial. This result indicated that the source of Se in cropland soils was different from that of soils which was not cultivated or disturbed by human activities. It provided the strong evidence that local people ever baked soil on the Se-rich stone coal fires and then they dispersed these baked soils containing much more higher dissoluble Se and insoluble native Se over the cropland to fertilize soil. This cultivated practice, ever used by villagers lived in Yutangba and other high-Se areas in Enshi, introduced abruptly a large amount of Se into their cropland, which is further accumulated in local people's food chain. The occurrence of native Se crystals in Yutangba cropland soils explains the source of Se in soils and the reason for the sudden incidence of human Se poisoning in 1963.

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Sn/W-bearing A-type granites in Nanling Range, South China

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There exists an early Yanshanian (J₁-J₂) Sn/W-mineralized A-type granite belt in Nanling Range, South China. It extends from Huashan, Guposhan, through Jiuyishan, Qitianling, Qianlishan up to Xitian in a NE direction for some 400 km. The total granite exposure area is over 3000 km².

These granitic bodies are accompanied with the contemporary dioritic and monzonitic stocks and rhyolitic volcanics. The mafic microgranular enclaves with magma mixing features are very common. In general, the granitic bodies can mostly be divided into two intrusive phases: the coarse-grained major phase (mainly 163~156 Ma) and the fine-grained later stage additional phase (mainly 143~151 Ma).

The granite rocks are very acidic in composition, (SiO₂=67.89~77.11%), rich in K₂O (3.99~6.29%) and alkalis (K₂O+Na₂O=7.38~9.62 %), slightly meta-aluminous to weakly peraluminous (ACNK=0.92~1.10).

In trace elements, all the major phase granites and the contemporary intermediate stocks and mafic enclaves are enriched in Rb, Cs, U, Th, LREE, Y, Nb, Ta, Zr, Hf, Ga etc LILEs and HFSEs, as well as Sn/W. They belong to aluminous A-type granites. Compared with the major phase granites, the later stage granites are more acidic (SiO₂>76%), more alumina-saturated (ACNK=1.00~1.21), and more enriched in Rb, Cs, U, Th, Y, Sn, W etc. trace elements, but relatively depleted in LREE, Zr etc. HFSEs. These later stage granites are often Sn/W-mineralized with large even giant tonnage. Chemically these rocks are very close to S-type granites.

The J₁-J₂ time in Nanling Range region was a post-orogenic extensional geotectonic setting. Upwelling of the asthenospheric mantle along the NE-trending deep faults resulted in melting of lower crust. The mantle fluid/melt may bring in Sn/W etc. ore-forming elements and mobilize them from the basemental rocks. The higher back-ground Sn/W concentration in melted protoliths and well evolved fractionation of granitic melts are also necessary prerequisites for formation of industrial Sn/W deposits.

Fe isotope variations in North Pacific deep water over last 80Ma

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Fe-Mn crust has proved to provide excellent records of isotope composition of dissolved Fe in deep seawater. Investigating the variability of Fe isotope composition of Fe-Mn crusts is an important approach to trace Fe cycling in marine environments.

A crust named CLD01 (160°44'24"E, 21°45'N, water depth = 2210 m) from the central North Pacific has been selected for Fe isotope study. This crust has been subjected to detailed investigation in terms of radiogenic isotopes, and its age has been constrained using multiple approaches extending to ca. 80Ma (Ling *et al.*, 2005). The sub-samples were obtained by micro-milling, and Fe isotope measurements were performed using a Nu Plasma HR MC-ICPMS at high-resolution mode after chemical purification. The results are expressed in ϵ units which are deviations in parts per 10⁴ from the same isotope ratios of the reference material IRMM-14. The overall variations in $\epsilon^{57/54}\text{Fe}$ units are from -8.8 to 0.9, within the range of Fe isotope composition of Fe-Mn crust reported before. In more detail, the Fe isotope compositions of the crust start with -3.6 $\epsilon^{57}\text{Fe}$ units at the surface, broadly increase to maxima of 0.9 at ca. 50Ma, then decrease sharply to -8.8 at ca. Ma. Furthermore, the $\epsilon^{57}\text{Fe}$ values obtained from the crust are negatively correlated with ^{206/204}Pb and ^{208/204}Pb ratios.

These results illustrate for the first time that the evolution of Fe isotope composition in North Pacific seawater back to latest Cretaceous, and confirms that the average Fe isotope composition in seawater is light relative to the bulk silicate Earth. In general, the main Fe sources for open oceans are terrestrial aerosols and MOR hydrothermal plumes. The crust studied is far away from MOR, and there is no evidence of MOR hydrothermal contribution in terms of Pb- and Nd-isotopes. While the exact reason why the overall Fe isotope composition in seawater as recorded in Fe-Mn crusts is lighter than bulk silicate Earth remain to be investigated, it is interesting to note that the Fe isotope compositions of precipitates resulting from Fe(III) hydrolysis are significantly lighter than those of residual solutions. The main turning point in the trend of Fe isotope variation occurs at ca. 50Ma, which is broadly coincident with the switchover of terrestrial inputs from North America to Asia (Ling *et al.*, 2005). The strong linkage between Fe- and Pb-isotope compositions strongly suggests that Fe isotope variation in North Pacific deep water is related with global climate change through source inputs.

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He isotope data evidence of crust contamination for mantle melts resulting to the PGE mineralized layered basic intrusions

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He isotopic composition of magmatic fluids from various PGE mineralized layered basic intrusions have been studied for understanding the role of mantle-crust interaction in formation of large Pt-Cu-Ni deposits. ³He/⁴He ratio have been obtained for Noril'sk, Talnakh, and Cheneisky PGE mineralized layered basic intrusions (Russia), as well as for the Bushveld Complex (South Africa). All our results have been compared with He isotopic data of Hawaiian and Icelandic basalts and others no mineralized small basic intrusions of the Noril'sk Region (Basu *et al.*, 1995).

³He/⁴He ratio is a sensitive indicator of crust substance contamination for mantle melts in processes of magmatic ores formation. ³He/⁴He value >8-10*10⁻⁶ corresponds to mantle He, while <1*10⁻⁶ value is connected with crust source. These ratio values up to 1-8*10⁻⁶ are typical for mixture of mantle and crust He in fluids.

It is important to note, that only basalts and very small basic intrusions with pure ore mineralization contain mantle He, whereas crust He is predominant in all the large Pt-Cu-Ni deposits from layered basic intrusions. This result correlates well with S and C isotopic data (Riabov *et al.*, 2001).

The results obtained give us a possibility to suggest that crust contamination of mantle melts is one of the important factor in formation of large and unique Pt-Cu-Ni deposits for layered basic intrusions.

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Geochemical and mineralogical pattern recognition and modelling with Bayesian approach at the hydrothermal gold deposits

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The Bayesian approach is an effective method of identifying the certain probability mineralogical and geochemical type mineralization on trace element in galen, pyrite and other distribution ore mineralization. Monomineral samples have been identified using computer upon Bayes method and exploration geochemical techniques of gold deposits for MGT. In order to realize the method, we have used a data bank consisting the results of analysing more than 12000 monomineral samples collected from main hydrothermal gold deposits on territory of CIS. Bayes approach applied to geochemical data such as posteriori probabilities and discriminate analysis provide a numerical and graphical means through which the relationships of the trace elements and samples can be studied. These methods were used here beside GIS to find MGT that can be used as geochemical indicators of regions with gold mineralization.

The results of analyzing 100 monomineral samples of pyrite from Au-Ag Shkolnoe deposit (Tajikistan) reveals multiformal anomaly of superposition which is a combination of three MGT as:

1. Gold - silver type (85 % and more)
2. Gold- sulfide - polymetallic type (46 %).
3. Gold - sulfide type (40 %).

Mineralogical and geochemical maps (MGM) are results of generalization and analysis of MGT and GIS of different objects. There arises the possibility of quantitative modeling using spatial links of objects and multivariate models helps significantly in making optimal managerial decisions that give maximum economic effect.

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Influence of hydrothermal crustal fluids on deep-biosphere populations

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Seawater that circulates within the upper porous layers of the ocean crust is forming the largest aquifer on earth. These hydrothermal crustal fluids are supposed to fuel the deep biosphere within deeply buried sediments by introducing electron acceptors for anaerobic respiration from below. To test this hypothesis, we have analysed sediment samples microbiologically that were collected during IODP Exp. 301 to the eastern flank of Juan de Fuca Ridge, an ocean spreading zone in the northeast Pacific. The 265 m long sediment column at IODP Site U1301 (water depth: 2656 m) is characterised by a diffusive flow of fluids from the underlying basalt, a steep temperature gradient of 0.23 °C/m and two sulfate-methane transition zones (SMTZ).

The cell counts generally decreased with the sediment depth. However, elevated numbers were found around the SMTZ and towards the ocean crust. Radiotracer measurements of sulfate reduction and anaerobic oxidation of methane (AOM) at near *in situ* temperatures were elevated in fluid-influenced layers. While sulfate reduction was a dominating process within the upper sediments, in deeper layers AOM rates were up to five times higher with a maximum around the lower SMTZ. As a more general measure for metabolic activity, potential phosphatase rates increased in phosphate-depleted layers towards the sediment-basement interface. Further investigations were focussed on the cultivation of indigenous microorganisms for subsequent analyses of their adaptations to the environment. So far, sulfate-reducing bacteria were enriched from both, the seawater and the fluid-influenced sediment zones. Molecular screening of enrichment cultures via PCR-DGGE revealed that completely different microbial communities thrive within the different zones.

Our studies confirm that metabolic activities and microbial community structures are influenced by fluids from the ocean crust. Regarding the worldwide expansion of the crustal fluid aquifer, we assume that this impact is a major driving force for marine deep-biosphere populations on a global scale.

Instrumental mass fractionation overcome by total evaporation

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A select suite of isotopes, including Li, Cu, V, Lu, and Re, along with isotopic mixtures of unknown isotopic composition, require special analytical techniques to overcome instrumental mass fractionation (IMF). Generally, measurements subject to IMF are corrected using a known ratio either intrinsic to the system or externally added to the sample and measured simultaneously with the sample. For many systems, e.g. Os, and for many types of measurements, e.g. ICP-MS, internal ratios or doping works well. For other cases, e.g. NTIMS Re measurements, neither approach readily works. Therefore, following the work of Suzuki *et al* [1], an updated total evaporation (TE) technique is employed. In theory, if the entire sample is evaporated until exhaustion and all the ions collected, mass fractionation is overcome, thereby improving accuracy and precision, with less dependence on the analyst.

An experiment was designed to test TE against single-collector peak jumping and multi-collector static measurements using a variety of ¹⁸⁵Re/¹⁸⁷Re ratios (~0.6 standard; ~4 sample; ~37 spike) with the expectation of documenting differences in measured ratios due to variability caused by IMF. Preliminary results demonstrate, within statistical uncertainty, that TE provides equally accurate, equally precise data that is marginally less dependent on the analyst.

While the initial results did not indicate a drastic improvement in accuracy or precision, further optimization of the analytical procedure may result in better data. NBS peak jumping, and to a lesser extent Triton static collection, have undergone multiple filament warm-up, focusing, and centering optimizations during thousands of Re measurements. On the other hand, TE measurements are currently utilizing default parameters. Optimization of procedures and parameters including filament heating; ideal initial, final, and maximum intensities; heatslope (mA/cycle); integration time; and mathematical constants is on-going. Fine-tuning these parameters and procedures should result in higher quality data, surpassing other data collection techniques.

Total evaporation may be extended to other isotopic systems including Li, B, Cu, Ir, V, Br, and Lu. Additionally, total evaporation may provide improved accuracy and precision for artificial isotopic mixtures such as double spikes (e.g. Os, Mo, and Pb). In summary, TE provides an alternate method of data collection for samples subject to, but not internally or externally correctable for, IMF.

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Formation of 4.5 Ga continental crust

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Geochemical models of crustal growth on early Earth have tended to favor mafic over felsic compositions for a variety of reasons including: lack of a mechanism to produce stable continental-type crust from a magma ocean (high ρ of feldspar w.r.t. hydrous melt, low feldspar growth rate w.r.t. convective vigor), problems reconciling Sm-Nd systematics, apparent inconsistency with Nb/Th/U ratios, and the absence of >4 Ga crust. However, Morse (1987) proposed a model that transcends most of these objections. He invoked a sinking, undercooled, two-phase plume that, upon reaching the base of a magma ocean, rapidly crystallizes olivine. The light, evolved liquid produced (assuming that the fluid in equilibrium with olivine is silica-rich at high P) ascends to shallow depths. Nucleation from sparse centers in the highly polymerized melt results in rapid crystallization of tonalitic rockbergs that coalesce into regions of stable, felsic crust. Recent Lu-Hf results on Hadean zircons tend to support the case for an early continental-type crust. Thus we have re-evaluated this proposal for the case of a ~250 km deep magma ocean using recent experimental data in conjunction with the MELTS program. Melting experiments in the CMAS system at 6.5 GPa and 1850°C (Asahara & Ohtani, 2001) yield liquid compositions characterized by 45-52% SiO₂. We modified the liquid composition by adding Fe to achieve MgO/(MgO+FeO)=0.8 and partitioning pyrolite levels of incompatible elements (e.g. K, Na) into the melt. Upon ascent to 0.2 GPa, the hygroscopic liquid containing 2% H₂O rapidly evolves during cooling to produce a dioritic (57% SiO₂) composition at 950°C. Thus an early felsic crust appears feasible even without the disequilibrium effects of the Morse model. He emphasized that a network-rich liquid would be characterized by a relatively high viscosity enabling the 'pop-up' crust to maintain sufficient mechanical integrity to resist remixing with the ultramafic magma ocean until rapid crystallization occurred. At the surface, proto-crust would tend to migrate to down-welling loci and be stabilized by the locally cooler conditions. As the base of the crust heats up in response to shutdown of the descending cell, felsic liquid produced would tend to ascend diapirically to shallow levels creating a feedback that sustains the presence of continental-type crust. Most of the arguments against an early continental-type crust described above lack rigor or have been transcended by recent evidence. Morse's (1987) model provides a plausible mechanism to produce felsic crust in the earliest stages of Earth evolution. Subsequent re-working and eventual recycling of this proto-continental crust into the mantle provides an explanation for the isotopic characteristics of Hadean zircons and the apparent absence of pre-4 Ga continental crust.