Radiogenic and non-traditional isotopic tracers of subsurface CO_2

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Although there are many reasons to believe that large-scale sequestration of CO_2 in subsurface geologic reservoirs can be successfully developed as a climate change mitigation strategy, there are still many issues and protocols that need to be worked out in both the short and longer term. In particular there is a need for methods to monitor and verify the location and amount of CO_2 injected and its post-injection fate and transport. This need in turn requires information about the form in which CO_2 is stored – as a separate liquid phase, dissolved in brine, or converted to minerals. Acquiring the necessary information will be challenging; if it can be acquired it is likely to come from a combination of remote sensing – e.g. seismic imaging or geodetic monitoring, and subsurface fluid sampling. In both cases the information obtained will be indirect and require interpretation. In the case of fluid sampling, isotopic analysis can be useful because there are a large number of candidate elements that have natural isotopic variations, and the combination of radiogenic and mass-dependent effects make then sensitive to most of the processes that will be operating in the subsurface. The isotopic compositions of C, H, and O are useful for measuring interactions between the CO_2 phase and brine, as are noble gas concentrations and isotopes. This presentation will focus more on other radiogenic and non-traditional stable isotope systems. For example, mineral dissolution can be reflected in the isotopes of Sr, C, Pb, and U, and the U may also provide information about the mineral reactive surface area that is being contacted by fluids. Fe isotopes have been shown to be sensitive to dissolution of Fe minerals and steel piping, and S isotopes are sensitive to dissolution and precipitation of sulfides and sulfate minerals. Ca and Mg isotope variations in fluids are sensitive to mineral precipitation. In most cases, the relevant isotopic effects are sensitive to kinetics, in that they provide information on actual chemical reaction rates as in the case of Sr and U, or that the fractionations themselves are dependent on reaction rates (Ca, Mg). Recent experimental work is helping to quantify the effects of precipitation kinetics and fluid phase diffusion and thermal gradients on mass-dependent isotopic fractionations, and these may also be useful for understanding the processes affecting subsurface CO_2.

Bimodal complexes of the Mongolian-Okhotsk orogenic belt (Western and Eastern flanks)

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The geodynamic model of the formation of PZ_3-MZ_1 bimodal complexes of the western flank of the Mongolian-Okhotsk belt lies in the parallel existing conditions of collision between North Asian and Sino-Korean continents conjugated with the closure of the Western part of Mongolian-Okhotsk basin and the influence of a plume on the site being under conditions of the collision compression [3]. On the East in the Mongolian-Okhotsk basin in PZ_3-MZ_1 sedimentation has being taken place. Only in the end of K1 (119-97 Ma) the rocks of the contrasting composition (subalkali basalts - rhyolites) [2] were formed along the soutern rim of the belt. All the rocks of the complex are enriched in LREE (La/Yb=5.5-33.0) at lower Nb (0.1-0.4 ppm), Ta (0.1-0.7ppm), Ti (0.01-0.09ppm) and at higher values of Ba, Rb, Th, K, Sr, Pb. These peculiarities are characteristic of all PZ_3-MZ_1 intraplate rocks of North Asia [1]. But in the east the large bodies of granitoid batholiths and alkali-salic occurrences are not present; in the rocks Nb, Ta, Zr, Hf concentration are lower. A characteristic feature of a mantle source of the bimodal complexes rocks of the Central Asia is the lower values of Zr/Hf=38-50 [1]. For the rocks of the eastern flank Zr/Hf is 34-52 and the ratios of $^{87}Sr/^{86}Sr$ are (0.7057-0.7063, 0.7081-0.7084) at $\varepsilon Nd_{(T)}$=(-0.6)–(-3.6). The values (+) ΔNb [4] for the basic rocks and the ratios of (La/Sm)n=2.9-5.7 and (Ce/Yb)n=11.6-25.5 are the evidence of the impact of the plume source. By $^{87}Sr/^{86}Sr$ - $\varepsilon Nd_{(T)}$ ratio the rocks of the eastern flank are comparable with the intraplate rocks of the Central Asia PZ_3-MZ_1.

Bimodal complexes, that accompany the formation of the rifting zones in framer of the Western flank of Mongolian-Okhotsk belt correlated with bimodal formations of the Eastern flank of the complex by the raw of geochemical, isotopic characteristics. But the period of the formations of the rocks on the West correspond the end of early Cretaceous. If one takes as a fact, that all the bimodal complexes were formed at similar geodynamical conditions, it can be assumed, that the closing-time of the Eastern flank of Mongolian-Okhotsk basin occurred in the end of early Cretaceous: 119-97 Ma.

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