

## Kinetic experiments of actinolite in $\text{CaCl}_2$ – $\text{HCl}$ – $\text{H}_2\text{O}$ up to $400^\circ\text{C}$

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Actinolite dissolution rates in  $\text{HCl}$ – $\text{H}_2\text{O}$  and  $\text{CaCl}_2$ – $\text{HCl}$ – $\text{H}_2\text{O}$  were measured at temperature ranging from 25 to  $400^\circ\text{C}$  and at 23 MPa. The dissolution experiments were performed in a flow-through reactor. The results provide new insight into the rate limiting reactions governing actinolite dissolution behavior at far from equilibrium, particularly at temperatures above  $300^\circ\text{C}$ . As actinolite dissolves in aqueous solutions, the relative release rates for breaking various metal–oxygen bonds in actinolite are different. Results show that Ca, Mg, Fe and Al dissolve faster than Si at temperatures of 25– $300^\circ\text{C}$ , but slower at  $300^\circ\text{C}$ . Ca and Mg release faster than Si at temperatures of  $350^\circ\text{C}$ – $374^\circ\text{C}$ . All of release rates vary with temperatures and pH. The release rate of Si increases with temperature from 20 to  $300^\circ\text{C}$ , and then decreases with continued increasing temperature from 300 to  $400^\circ\text{C}$ . The maximum release rate of Si is reached at  $300^\circ\text{C}$ . Experiments show that dissolution stoichiometry of actinolite is affected by temperature and pH. Results of actinolite dissolved in  $\text{CaCl}_2$ – $\text{HCl}$ – $\text{H}_2\text{O}$  indicate that the release ratios of  $m_{\text{Ca}}/m_{\text{Si}}$  and  $m_{\text{Mg}}/m_{\text{Si}}$  in the effluent at  $200^\circ\text{C}$  are close to stoichiometric number of these element moles in one mole of actinolite and actinolite dissolution in  $\text{HCl}$ – $\text{H}_2\text{O}$  at  $100^\circ\text{C}$  is close to the stoichiometric.

The reacted surfaces of actinolite are observed using EPMA, HRTEM, SEM and XPS. The surface after reacted at temperature  $<300^\circ\text{C}$  is quite different from that after reacted at  $\geq 300^\circ\text{C}$ . At temperature  $\geq 300^\circ\text{C}$ , metal-hydrogen exchange reaction is weak and the release rates of Si increases. HRTEM and SEM studies indicate that a Fe (Al)-rich, Si-deficient layer is formed at surface. Experiments prove that each metal–oxygen bond within the silicate structure breaks at a distinct rate, which is affected by temperature. XPS and SEM-TEM study indicates that the surface layer after reacted at  $300$ – $400^\circ\text{C}$  is not only amorphous, but also hydrated silicate, composed of Si–O–Si, Si–OH, and Si–O bonds. This project is supported by the project of k[2013]01-062-014, SinoProbe-07-02-03, SinoProbe-03-01-2A and 2010G28.

## Hydrocarbon geology characteristics and exploring prospect of ultradeep layers onshore China

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As the geology knowledge becoming deeper and the exploring technology developing, the hydrocarbon exploring prospect in deep-ultradeep layers is being recognized by the world. Chinese petroliferous basins suffered divergency in Eopaleozoic, transition between marine and continent in Neopaleozoic, and strong compression in Meso-cenozoic. The basins are mainly superimposition basins, which have upper and lower tectonic layers. Previous exploration mainly focus on upper layer, in recent years, CNPC has achieved a series of discoveries in deep-ultradeep layers of petroliferous basins onshore China through strengthening hydrocarbon geology research and discovery in deep layers, which shows great prospect of hydrocarbon exploring in deep layers. Basing on newest exploring results and research, it can be proposed that: ① There are two kind of sources, normal source rock and inner source resident liquid hydrocarbon cracking, which can provide hydrocarbon, causing the deep layer resource potential may be out of our expectation. ② Deep-ultradeep layers onshore China are affected by several geological factors. In the deep layers of superimposed basins, there are carbonate, volcanic and clastic reservoirs. ③ Large area of accumulation can happen in carbonate rocks, clastic rocks and volcanic rocks in deep-ultradeep layers. The reserve abundance is not so high but the scale can be very large. ④ The exploring degree in deep layer onshore China is low and the remaining resource is high, it can be predicted that the deep layers onshore will become an important replace area for the oil and gas industry of our country.