# The heat relaxation *P-T-t* path of HP-UHP eclogites from Chinese southwestern Tianshan: constraints from *P-T* pseudo- sections, Lu-Hf and Sm-Nd isochron dating

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Abstract: The southwestern Tianshan orogenic belt is one of the rare preserved ultrahigh pressure metamorphic belts formed by oceanic subduction in the world. However, its *P-T-t* path is poor constrained. In this study, four representative eclogite samples, i.e., three paragonite-epidote eclogites (Sample 211-3, H505-26 and H76-10) and one glaucophane-phengite eclogite (Sample H711-1), are selected for combined study of Lu-Hf and Sm-Nd geochronology as well as a detailed phase equilibria modeling. Porphyroblastic garnet in these four samples shows well-preserved growth zoning with the content of pyrope increasing and that of spessartine decreasing from core to rim. Phase equilibria modeling indicates that garnet in eclogites from Chinese southwestern Tianshan grew in the lawsonite-bearing eclogite facies during heating accompanied by either compression (e.g. H505-26) or decompression (e.g. 211-3, H76-10 and H711-1). Estimated peak pressures of 24-29kbar with a coesite pseudomorphs suggest that some eclogites underwent UHP metamorphism (e.g. 211-3). Peak temperatures of 490-560°C are below the closure temperature of the Lu-Hf and Sm-Nd systems. The garnet-omphacite-whole rock Lu-Hf and Sm-Nd isochron ages, therefore, are interpreted to reflect garnet growth, i.e., HP-UHP eclogite facies metamorphism. Sample 211-3 yields a Lu-Hf isochron age of 326.9±1.3Ma which represents the first reported Lu-Hf age for UHP metamorphism in Chinese southwestern Tianshan. Another valid Lu-Hf age of 306±11Ma for Sample H76-10 and three consistent Sm-Nd isochron ages of 309±4.6Ma, 306±15Ma and 305±11Ma for Samples H505-26, H76-10 and H711-1 are obtained, reflecting high pressure eclogite facies metamorphism. Based on these new ages, a clockwise *P-T-t* path with heating during exhumation is obtained for HP-UHP eclogites from Chinese southwestern Tianshan, in conjunction with detailed phase equilibrium studies and previous geochronological data. This heat relaxation P-T-t path of HP-UHP eclogites indicates the slow exhumation and long journey for the heavy oceanic HP-UHP eclogite. We propose that subduction of the paleo-South Tianshan ocean began before 346Ma, blueschist-eclogite facies prograde metamorphism of subducting oceanic crust occurred at 346-333Ma, peak eclogite facies metamorphism occurred at 327-305Ma, and buoyancy-driven exhumation of subducted oceanic crust occurred at 296-226Ma.

# The δ $^{18}$O signals of precipitation and drip water:Two hydrological years' monitoring results from eight caves in monsoon regions of China

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To better interpret the $\delta^{18}O$ proxy of Chinese speleothems, a joint monitoring program has been carried out at eight cave sites in monsoon regions of China (fig1) since 2011.
Here we outline preliminary conclusions as follows:

1. At any monitoring cave sites, precipitation $\delta^{18}O$ does not show significant amount/temperature effect at seasonal or inter-annual scale.

2. At five of six cave sites in South China, the mean annual precipitation $\delta^{18}O$ is heavier in 2012 than in 2011, which is consistent with that the short-distance source water vapor from West Pacific Ocean to China is larger in 2012 than in 2011[1]. But specially, at Xianren cave site, the $\delta^{18}O$ behaves oppositely versus other five sites, most likely because the West Pacific Ocean is a long-distance water source for this westerly farther location. While at Shihua cave and Wanxiang cave in North China, the mean annual precipitation $\delta^{18}O$ is roughly equal in the two years. Therefore, under inter-annual variation, the monitoring results from the southern caves supports the idea on the "circulation effect" of precipitation $\delta^{18}O$ [2], while, from the northern caves, they are ambiguous.

3. At most of the monitoring sites, the depleted summer precipitation $\delta^{18}O$ signals are greatly smoothed when waters filter into caves. Accordingly, vadose zone plays a significant role in modifying the $\delta^{18}O$ signals of drip waters[3].

[1]http://www.itmm.gov.cn/grapes/jcgb. [2]Tan (2013) Clim Dyn, doi:10.1007/s00382-013-1732-x.[3] Luo & wang (2008) Chin Sci Bull 53,3364–3370.

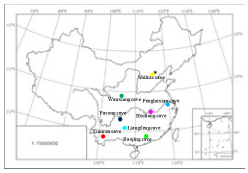

Figure1: Locations of the eight caves mointored in this study.

www.minersoc.org
DOI: 10.1180/minmag.2013.077.5.4