Contrasting *REE* geochemical features between Archaean and Proterozoic khondalite series of North China Craton

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Taylor and Mclennan (1985) have thoroughly described the sedimentary *REE* geochemical transition from Archaean to Proterozoic, i.e. from positive or slight Eu-anomaly to clear Eu-depletion. Gibbs *et al.* (1986), Condie (1993) and other researchers have proved wrong the views of Taylor and Mclennan. They argue that the transitions have been deduced from an incorrect comparison of Proterozoic platform-type sediments with those from Archaean greenstone, as if comparing an orange with an apple. To verify their views, we have studied the *REE* geochemical characteristics of khondalite series of the Archaean and Proterozoic of the North China Craton (NCC) and found great differences between them.

Ages and spatial distribution of the khondalite series in the North China Craton

All the khondalite series of the NCC had long been regarded as Archaean. Since Chen (1990) argued that most of the khondalite series in China formed during 2300–2050 Ma, nearly all the khondalite series have been universally accepted as Palaeoproterozoic in age, except for the Fuping Group in the Taihang Mountains. The Fuping Group is distributed in the core of the NCC, the others along the its rim. Possessing less graphite and less BIF, the Fuping Group is different from the Proterozoic khondalite series.

REE geochemistry of the khondalite series

As shown in Table 1, the khondalite series in various districts of the NCC have been studied. Sedimentary rocks of different kinds from Proterozoic khondalite series show clear negative Eu-anomalies, with Eu/Eu* averages ranging from 0.52 to 0.72, remarkably similar to PAAS or NS. Only one sample of kyanite gneiss from the Jingshan Group, Jiaodong block, shows a strong positive Eu-anomaly (Eu/Eu* = 3.49). The other geochemical features of *REE* and trace elements are also consistent with PAAS (Taylor and Mclennan, 1985).

Marbles of the Archaean khondalite series, Fuping Group, are characterized by positive Eu-anomaly. Neither felsic gneisses nor amphibole gneisses show clear Eu-depletion, their average Eu/Eu* values being 0.89 and 0.85 respectively. The *REE* patterns are similar to Archaean shales (Taylor and Mclennan, 1985).

Discussions

The obvious differences in *REE* geochemistry between the Archaean and Proterozoic khondalite series of the NCC strongly support geochemical transition from Archaean to Proterozoic (Taylor and Mclennan, 1985). To explain this transition, most Chinese scholars appeal the theory advanced by Taylor and Mclennan (1985). The authors refer to the Oxidation-Reduction Model (Chen and Fu, 1991), i.e. Archaean reducing conditions result in the positive or slight Eu-anomalies of Archaean sediments, and post-2300 Ma oxic environment led to sedimentary Eu-depletion (especially for chemical sediments). However, these two different explanations could not reveal the origin of the positive Eu-anomaly of the kyanite gneiss from the Jiangshan Group.

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TABLE. 1. *REE* geochemical characteristics of the khondalite series in the NCC

Stratigraphy and location	Petrology	Num.	Data source	Eu/Eu*	*REE*	$(La/Yb)_N$
Shuidgou Group, Huaxiong block	graphite and, sillimanite-garnet gneiss,	8	the authors	0.30–0.69 (0.59)	102.74–211.17 (141.7)	1.03–46.90 (11.28)
Shuidgou Group, Huaxiong block	graphite-marble	1	the authors	0.72	74.35	17.27
Jingshan Group, Jiaodong block	garnet gneiss, BIF, graphite gneiss	9	the authors	0.32–1.10 (0.67)	137.49–378.99 (212.6)	2.7–12.2 (7.0)
Jingshan Group, Jiaodong block	marble	1	the authors	0.70	34.57	19.0
Jingshan Group, Jiaodong block	kyanite gneiss	1	the authors	3.49	86.68	35.1
Fenzishan Group, Jiaodong block	gneiss	6	the authors	0.43–1.08 (0.64)	107.67–219.91 (156.3)	3.5–14.6 (9.2)
Helanshan Group, Alashan block	Al-rich gneiss	9	Hu and Yang, 1995	0.30–0.65 (0.52)	150.7–280.5 (216.7)	8.3–54.0 (11.0)
Helanshan Group, Alashan block	leptynites	8	Hu and Yang, 1995	0.53–1.27 (0.65)	36.3–240.1 (152.3)	8.4–32.3 (16.2)
Jining Group, Daqingshan area	gneiss	4	Jin and Li, 1994	0.47–0.88 (0.62)	272.80–333.0 (312.97)	?
Jining Group, Datong area	sillimanite-garnet gneiss	6	Condie *et al.*, 1992	0.43–0.78		
Sanggan Group, Wulashan area	sillimanite-garnet gneiss	9	Li *et al.*, 1994	0.42–0.87 (0.64)	63.85–350.82 (205.67)	4.68–27.08 (15.03)
Fuping Group, Taihang Mountain	marble	2	Wu *et al.*, 1989	0.97–1.78 (1.38)	69.28–133.44 (101.36)	19.43–23.92 (19.42)
Fuping Group, Taihang Mountain	felsic gneiss	13	Wu *et al.*, 1989	0.42–1.37 (0.89)	53.81–1168.77 (222.55)	11.49–38.67 (18.38)
Fuping Group, Taihang Mountain	amphibole gneiss	10	Wu *et al.*, 1989	0.71–0.95 (0.85)	58.85–167.29 (112.40)	2.66–5.98 (4.75)

Averages in parentheses

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