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Reply to the comment on Lee et al., "Detrital zircon geochronology and Nd isotope geochemistry of the basal succession of the Taebaeksan Basin, South Korea: Implications for the Gondwana linkage of the Sino-Korean (North China) block during the Neoproterozoic–early Cambrian" [Palaeogeography, Palaeoclimatology, Palaeoecology 441 (2016): 770–786]

Yong Il Lee [a,*], Taejin Choi [b], Hyoun Soo Lim [c]

[a] School of Earth and Environmental Sciences, Seoul National University, Seoul 151-747, Republic of Korea
[b] Department of Energy Resources Engineering, Chosun University, Gwangju 501-759, Republic of Korea
[c] Department of Geological Sciences, Pusan National University, Pusan 609-735, Republic of Korea

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ABSTRACT

In the comment on our paper, Cho and Cheong (2016) and Kim and Ree (2016) make a number of arguments that we did not discuss the Cambrian zircons from our data and have cast doubt on our early Cambrian paleogeographic reconstruction. They also argued that our data do not pass statistical tests between concerned strata for paleogeographic reconstruction. In response to the comment, we show that these arguments are not based on sound geological evidence and conditions that we provided in our paper.

We thank Cho and Cheong (2016) and Kim and Ree (2016) for their Comments on our recent paper (Lee et al., 2016a), which give us the opportunity to clarify our analysis of detrital zircon U—Pb geochronology and our subsequent interpretations. Cho and Cheong (2016) make five arguments: (1) detrital zircon ages younger than 520 Ma and Pb–loss possibility were not considered for interpretation, (2) significance of a single detrital zircon age from the Myeonsan Formation and magmatic-arc setting interpretation of Kim et al. (2013) need to be considered important, (3) the Kolmogorov-Smironov (K—S) statistical test results for interpreting sediment routing system for the Myobong, Sambangsan, and Mantou Formations are not supported by currently assumed paleotectonic setting of the Paleozoic Taebaeksan Basin, (4) the presence of Meso- to Neoproterozoic zircons in the Myobong Formation is not new, and (5) the depositional age of the Jangsan Formation is not Neoproterozoic, but early Cambrian as commonly thought.

Kim and Ree (2016) make the following two arguments: (1) a single detrital zircon age of the Myeonsan Formation of Kim et al. (2013) represents the depositional age of this formation and this age is constrained by the biostratigraphic age and (2) our K-S statistical test results are wrong and thus the paleogeographic interpretation based on these results is not valid. The comment raised by Kim and Ree are mostly overlapped with that of Cho and Cheong (2016): (1) and (2) of Kim and Ree (2016) can be discussed together with (1)–(2) and (3) of Cho and Cheong (2016), respectively. Thus we would like to reply to them together, not individually. Here we show that there are significant flaws in their arguments and address these points in order below.

(1) In our paper, Lee et al. (2016a), we assigned the depositional age of the Myobong Formation as 520 Ma based on the trilobite study of Kobayashi (1966). Kobayashi (1966) reported the first occurrence of trilobite, the *Redlichia* biozone from the Myobong Formation and interpreted that the depositional age of the Mybong Formation is late early to middle Cambrian. The

* Corresponding author.
E-mail address: lee2602@plaza.snu.ac.kr (Y.I. Lee).

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Table 1
(a) Results of Kolmogorov-Smironov (K—S) test run on the data from all samples (Korea, North China, South China, and Australia) for comparison reported in Lee et al. (2016a). Zircon aages older than 520 Ma were used for comparison (see text for details). *P* values larger than 0.05 are highlighted. 1) McKenzie et al. (2011), 2) Ireland et al. (1998), 3) Yao et al. (2011), 4) Wu et al. (2010), 5) Xu et al. (2013).
(b) Newly obtained results of Kolmogorov-Smironov (K—S) test run on the data from all samples (Korea, North China, South China, and Australia) for comparison in this study. Zircon aages older than 520 Ma were used for comparison (see text for details). *P* values larger than 0.05 are highlighted. 1) McKenzie et al. (2011), 2) Ireland et al. (1998), 3) Yao et al. (2011), 4) Wu et al. (2010), 5) Xu et al. (2013).

a

		South Korea				North China	Australia	South China		
		Jangsan Fm.	Myeonsan Fm.	Myobong Fm.	Sambangsan Fm.	Mantou Fm.1)	Carrickalinga Head Fm.2)	Chongyi Area3)	Wuyishan Foldbelt4)	Mt. Daming5)
South Korea	Jangsan Fm.		**0.219**	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Myeonsan Fm.	**0.219**		0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Myobong Fm.	0.000	0.000		**0.362**	**0.961**	**0.063**	0.008	0.001	0.002
	Sambangsan Fm.	0.000	0.000	**0.362**		**0.696**	0.000	**0.274**	**0.095**	**0.119**
North China	Mantou Fm.1)	0.000	0.000	**0.961**	**0.696**		**0.069**	**0.194**	**0.083**	**0.132**
Australia	Carrickalinga Head Fm.2)	0.000	0.000	**0.063**	0.000	**0.069**		0.000	0.000	0.000
South China	Chongyi Area3)	0.000	0.000	0.008	**0.274**	**0.194**	0.000		**0.803**	**0.879**
	Wuyishan F.B.4)	0.000	0.000	0.001	**0.095**	**0.083**	0.000	**0.803**		**0.964**
	Mt. Daming5)	0.000	0.000	0.002	**0.119**	**0.132**	0.000	**0.879**	**0.964**	

b

		South Korea				North China	Australia	South China		
		Jangsan Fm.	Myeonsan Fm.	Myobong Fm.	Sambangsan Fm.	Mantou Fm.1)	Carrickalinga Head Fm.2)	Chongyi Area3)	Wuyishan Foldbelt4)	Mt. Daming5)
South Korea	Jangsan Fm.		**0.120**	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Myeonsan Fm.	**0.120**		0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Myobong Fm.	0.000	0.000		**0.337**	**0.945**	**0.068**	0.007	0.001	0.002
	Sambangsan Fm.	0.000	0.000	**0.337**		**0.696**	0.000	**0.274**	**0.095**	**0.119**
North China	Mantou Fm.1)	0.000	0.000	**0.945**	**0.696**		**0.069**	**0.194**	**0.083**	**0.132**
Australia	Carrickalinga Head Fm.2)	0.000	0.000	**0.068**	0.000	**0.069**		0.000	0.000	0.000
South China	Chongyi Area3)	0.000	0.000	0.007	**0.274**	**0.194**	0.000		**0.803**	**0.879**
	Wuyishan F.B.4)	0.000	0.000	0.001	**0.095**	**0.083**	0.000	**0.803**		**0.964**
	Mt. Daming5)	0.000	0.000	0.002	**0.119**	**0.132**	0.000	**0.879**	**0.964**	

Redlichia biozone forms the lowermost biozone among the four biozones of the Myobong Formation, which suggests that the minimum depositional age of the Myobong Formation is not younger than 509 Ma. *Redlichia* is found in Toyonian (513–510 Ma; Korovnikov, 2011; Gradstein et al., 2013) or Longwangmiaoan (521–518 Ma: Yu et al., 2001) aged strata. As the Myeonsan Formation underlies the Myobong Formation, we assumed that the depositional age of the Myeonsan Formation should be older than 520 Ma by considering the *Redlichia* biozone in China (Yu et al., 2001). Although Kim and Ree (2016) agree that a single zircon age is not statistically reliable, they kept arguing that Lee et al. (2016a) did not use eight concordant ages younger than 520 Ma for further discussion. The youngest single zircon that Kim et al. (2013) reported has an age of 512 $\pm$ 6 Ma with a discordance of 20%. As claimed, considering the error range this age may be in agreement with the supposed biostratigraphic age of the Myobong Formation. However, this age was reported from the Myeonsan Formation that underlies the Myobong Formation. Setting aside the younger age (ca. 510 Ma) of a single grain than the biostratigraphic age, one single grain age should not be used for any conclusions. Experience in geochronology laboratories in general dictates that one anomalous grain does not demonstrate the presence of a real population. Further, contamination is always possible. In addition, there is no a priori reason to assume that zircons having ages close to 510 Ma in our data have lost Pb slightly only during a short period of time as Cho and Cheong (2016) argued. The youngest zircon reported by Kim et al. (2013) may have been affected by metamictization caused by α-particles and fission, resulting in radiation damage and increasing chance for Pb loss (cf., Mezger and Krogstad, 1997). This may explain a discordance of this zircon grain. If this zircon is pristine and represents the syndepositional arc event, it may not record discordance (20%) since the time for lattice damage was too short. Thus, we did not discuss zircon ages younger than 520 Ma simply because they are younger than the inferred depositional age of the Myobong Formation. If the argument raised by Cho and Cheong (2016) and Kim and Ree (2016) is accepted, not only Cambrian population but also younger ages (Devonian, Carboniferous, etc.) should be also considered.

(2) (2) The Taebaeksan Basin and the Pyeongnam Basin in North Korea were part of North China Platform which was an extensive epeiric platform formed on the Sino-Korean Block during the early Paleozoic (Meng et al., 1997; Lee and Lee, 2003; Kwon et al., 2006). As Cho and Cheong (2016) agree in their Comment, the platform was tectonically stable during the Cambrian (Lee and Lee, 2003; Kwon et al., 2006). Then, this information is not consistent with their argument that the Taebaeksan Basin was located in an active continental margin by referring a magmatic-arc setting interpretation of Kim et al. (2013).
Sandstone classification of Kim et al. (2013) is not based on the classification of grain types for Dickinson et al. (1983)'s ternary diagram for discrimination of provenance types. Their interpretation that some Myeosan Formation sandstones plot in a magmatic arc provenance field and thus, they interpreted that the Myeonsan Formation was deposited in a magmatic arc setting. They treated abundant Fe—Ti oxide minerals as lithic fragments, but the original diagram utilizes only three components: quartzose grains, feldspar grains, and unstable lithic fragments. The unstable lithic fragment includes volcanic/metavolcanic lithic fragments and sedimentary/metasedimentary lithic fragments (Dickinson et al., 1983). The abundant Fe—Ti oxide minerals are heavy minerals like any other heavy minerals occurring as trace amounts in sediments/sandstones. Although they are abundant and thus are a good proxy to interpret provenance, they should not be used as a framework component for sandstone types and provenance discrimination diagrams. As Kim (1991) reported, the Myeonsan Formation contains very little lithic fragments mainly composed of sandstone, quartzite, schist, and gneiss, which is shown in Fig. 4 of Lee et al. (2016a). Also,