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Formation of the Giant Bayan Obo Deposit by ca. 1.3 Ga Carbonatitic Magmatism and its Link with Continental Rifting in the Columbia Supercontinent

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The Bayan Obo in the northern North China Craton is the world's largest light rare earth element (LREE) deposit and the largest niobium (Nb) and thorium (Th) deposit in China (e.g., Wu, 2008; Kynicky et al., 2012; Ling et al., 2013; Smith et al., 2015). It is hosted mainly in carbonatite sills emplaced into the sedimentary rocks of the late Paleoproterozoic-Mesoproterozoic Bayan Obo Group. A deeper understanding of the timing and origin of the Bayan Obo deposit is of global importance and may be a critically important guide in the location of future resources. However, timing and genesis of the Bayan Obo deposit is highly controversial for many decades (e.g., Drew et al., 1990; Chao et al., 1992; Yuan et al., 1992; Wang et al., 1994; Le Bas et al., 2007; Wu, 2008; Ling et al., 2013; Fan et al., 2014; Smith et al., 2015; Zhu et al., 2015). Here we report a precise zircon $^{208}Pb/^{232}Th$ age of 1301 ± 12 Ma (N = 47, MSWD = 2.2) for a REE-Nb-Th-rich carbonatite sill from the Bayan Obo deposit. Zircon morphology, trace element compositions and mineral inclusions demonstratively show that the above zircons were crystallized from REE-Nb-Th-rich carbonatitic magma and their ages represent timing of carbonatites and REE-Nb-Th mineralization. The above new ages are consistent with the field occurrence of REE-Nb-Th-rich carbonatite in the Bayan Obo deposit. Therefore, the Bayan Obo REE-Nb-Th deposit is a product of mantle-derived carbonatitic magmatism during the Mid-Mesoproterozoic period at ca. 1.3 Ga. Field relations show that emplacement of the Bayan Obo carbonatites was accompanied by pre-magmatic uplift that is considered to be related to rifting to drifting transition. The Bayan Obo carbonatites and REE-Nb-Th deposit are spatially and temporally linked with the ca. 1.32 Ga Yanliao large igneous province in the northern North China Craton (Zhang et al., 2016) and were related to continental rifting that have led to breakup of the North China Craton from the Columbia supercontinent. Geological corrections and paleomagnetic reconstructions show that there could be some genetic connections between the Bayan Obo and the world's second largest Mountain Pass REE ore deposits in North America (e.g., DeWitt et al., 1987; Castor et al., 2008; Mariano and Mariano Jr., 2012) during the Mid-Mesoproterozoic continental rifting events in the Columbia supercontinent.

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References

Castor, S.B., 2008. Rare earth deposits of North America. *Resource Geology*, 58: 337–347.

Chao, E.C.T., Back, J.M., Minkin, J.A., and Ren, Y.C., 1992. Host-rock controlled epigenetic, hydrothermal metasomatic origin of the Bayan Obo REE–Fe–Nb ore deposit, Inner Mongolia, PR China. *Applied Geochemistry*, 7: 443–458.

DeWitt, E., Kwak, L.M., and Zartman, R.E., 1987. U-Th-Pb and $^{40}Ar/^{39}Ar$ dating of the Mountain Pass carbonatite and alkalic

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igneous rocks, southeastern California. In: DeWitt, E. (ed.), *Proterozoic ore deposits of the southwestern U.S.* Society of Economic Geologists Guidebook Series 1, 55.

Drew, L.J., Meng, Q., and Sun, W., 1990. The Bayan Obo Iron-rare-earth-niobium deposits, Inner Mongolia, China. *Lithos*, 26:43–65.

Fan, H.R., Hu, F.F., Yang, K.F., Pirajno, F., Liu, X., and Wang, K.Y., 2014. Integrated U-Pb and Sm-Nd geochronology for a REE-rich carbonatite dyke at the giant Bayan Obo REE deposit, Northern China. *Ore Geology Reviews*, 63: 510–519.

Kynicky, J., Smith, M.P., and Xu, C., 2012. Diversity of rare earth deposits: the key example of China. *Elements*, 8: 361–367.

Le Bas, M.J., Yang, X.M., Taylor, R.N., Spiro, B., Milton, J.A., and Zhang, P.S., 2007. New evidence from a calcite-dolomite carbonatite dyke for the magmatic origin of the massive Bayan Obo ore-bearing dolomite marble, Inner Mongolia, China. *Mineralogy and Petrology*, 90: 223–248.

Ling, M.X., Liu, Y.L., Williams, I.S., Teng, F.Z., Yang, X.Y., Ding, X., Wei, G.J., Xie, L.H., Deng, W.F., and Sun, W.D., 2013. Formation of the world's largest REE deposit through protracted fluxing of carbonatite by subduction-derived fluids. *Scientific Reports*, 3(1776): 1–8, doi: 10.1038/srep01776.

Mariano, A.N., and Mariano, Jr. A., 2012. Rare earth mining and exploration in North America. *Elements*, 8: 369–376.

Smith, M.P., Campbell, L.S., and Kynicky, J., 2015. A review of the genesis of the world class Bayan Obo Fe-REE-Nb deposits, Inner Mongolia, China. *Ore Geology Review*, 64: 459–476.

Wang, J., Tatsumoto, M., Li, X., Premo, W.R., and Chao, E.C.T., 1994. A precise ^{232}Th-^{208}Pb chronology of fine grained monazite: Age of the Bayan Obo REE-Fe-Nb ore deposit, China. *Geochimica et Cosmochimica Acta*, 58: 3155–3169.

Wu, C., 2008. Bayan Obo controversy: carbonatites versus iron oxide-Cu-Au-(REE-U). *Resource Geology*, 58: 348–354.

Yuan, Z., Bai, G., Wu, C., Zhang, Z., and Ye, X., 1992. Geological features and genesis of the Bayan Obo REE ore deposit, Inner Mongolia, China. *Applied Geochemistry*, 7: 429–442.

Zhang, S.H., Zhao, Y., Li, X.H., Ernst, R.E., and Yang, Z.Y., 2016. The 1.32 Ga Yanliao large igneous province in the North China Craton: Implications for reconstruction of the Nuna (Columbia) supercontinent. *Geology* (in review).

Zhu, X.K., Sun, J., and Pan, C., 2015. Sm–Nd isotopic constraints on rare-earth mineralization in the Bayan Obo ore deposit, Inner Mongolia, China. *Ore Geology Reviews*, 64: 543–553.