Acta Geologica Sinica (English Edition), 2021, 95(4): 1415–1417

Research Advances

New Discovery of Ca. 38 Ma Ultramafic–mafic Dyke Swarms in the Mitizi Area, Northwestern Tibetan Plateau

CHAO Wendi[1,*], WANG Zuopeng[2], LI Xiaojun[1] and ZHOU Yanlong[2]

[1] *Northwest Geological Exploration Institute of China Metallurgical Geology Bureau, Xi'an 710119, China*
[2] *School of Earth Science and Resources, Chang'an University, Xi'an 710054, China*

Citation: Chao et al., 2021. New Discovery of Ca. 38 Ma Ultramafic–mafic Dyke Swarms in the Mitizi Area, Northwestern Tibetan Plateau. Acta Geologica Sinica (English Edition), 95(4): 1415–1417. DOI: 10.1111/1755-6724.14745

Objective

The Tibetan Plateau, located in the eastern part of the Alpine Himalayan tectonic domain, is the youngest and the most spectacular of all continent-continent collisional belts in the world (Zhang et al., 2007; Xu et al., 2011; Zhu et al., 2012). Over the past 20 years, Cenozoic potassic volcanic rocks and intermediate–felsic granitic plutons in the northwestern Tibetan Plateau have been extensively identified (Luo et al., 2006). However, there are no previous reports of Cenozoic ultramafic–mafic dykes in this region. Here we report the discovery of ca. 38 Ma ultramafic–mafic dyke swarms in the Mitizi area, which provides important new information on Eocene mantle activity on and tectonic uplift of the Tibetan Plateau.

Methods

Based on 1:50,000 geological mapping, we have carried out detailed investigations locating these newly identified dykes. Zircon U-Pb isotopic dating by LA-ICP-MS was carried out at the Key Laboratory for the Study of Focused Magmatism and Giant Ore Deposits, MLR, Xi'an Center of Geological Survey, CGS, using a system of a Geolas 200M equipped with a 193 nm ArF-excimer laser. During this process, Zircon 91500, GJ-1 and NIST610 were used as the reference materials for U-Pb dating and optimizing the instrument. Whole-rock geochemical analyses were determined using X-ray fluorescence (XRF) and inductively coupled-plasma mass spectrometry (ICP-MS) at the Chang'an University, Xi'an, China. Analytical errors for most elements are generally less than 3 wt%.

Results

The nearly E–W trending ultramafic–mafic dyke swarms are located in the northern margin of the Mitizi area, northwestern Tibetan Plateau (79°24′55.83"E, 36°38′ 12.90"N), and intruded into the Changchengian Sailajiazitage Group that is mainly composed of quartz schists and quartz bands (Fig. 1a, b). The dykes mainly consist of spessartite with mineral association of hornblende (45%–55%), plagioclase (30%–35%), and biotite (2%–4%). Hornblende phenocrysts generally show euhedral to subhedral forms with sizes ranging from 0.03 mm to 0.80 mm. Biotite phenocrysts are euhedral with sizes ranging between 0.02 mm and 0.60 mm, and some of them are altered to chlorite (Fig. 1c–e). Complex tectonic movements resulted in the occurrence of metamorphism in the matrix of these rocks. Detailed dating and geochemical features are as follows:

(1) Zircon crystals from the studied dykes are prismatic, transparent to translucent and subhedral. They are 150–50 μm long and 80–40 μm wide, with length/width ratios ranging from 3:1 to 2:1. In cathodoluminescence (CL) images (Fig. 1f), the zircons with high Th/U ratios (0.4–1.0) are characterized by a remarkable oscillatory zoning, consistent with an origin derived from a magma source. Analyses of 11 zircon grains yielded $^{206}Pb/^{238}U$ dates ranging from 36.1 Ma to 41.1 Ma (Appendix 1), with a weighted mean age of 38.2 ± 0.5 Ma (MSWD = 3.6; Fig. 1f). The latter is taken as the crystallization age of the ultramafic–mafic dyke swarms in the northwestern Tibetan Plateau;

(2) Geochemically, the ultramafic–mafic dyke samples are characterized by a limited range of SiO_2 content (45.08–49.17 wt%), high MgO (5.12–8.55 wt%), TiO_2 (2.21–4.56 wt%) and CaO (5.36–12.08 wt%), low K_2O (0.69–2.17 wt%) contents with relatively high Na_2O/K_2O ratios (1.51–3.76), mostly displaying a trend of a subalkaline series (Appendix 2). Moreover, they display relatively high ratios of $(La/Yb)_N$ (4.4–7.9) and $(Gd/Yb)_N$ (1.9–2.6), and exhibit slight enrichment of large ion lithophile elements, such as Rb and Ba, relative to the high field-strength elements (such as Nb, Ta, Zr and Hf);

(3) The studied dykes show low Sm/Yb (2.0–2.9) and Dy/Yb (1.3–1.7) ratios, suggesting their derivation from low degrees (1%–5%) of partial melting of a mantle source composed of garnet + spinel lherzolite (Fig. 1g, h; Zhao and Zhou, 2007). Compared with the primary magma, they show low MgO, Ni and Cr abundances, implying fractional crystallization of olivine and clinopyroxene during the magma ascent. The weakly positive Eu anomalies probably reveal that no significant fractional crystallization of plagioclase occurred;

(4) Luo et al. (2006) suggested that the mantle-derived magmas in the northwestern Tibetan Plateau were mainly related to large-scale strike-slip faults and mantle delamination. Our field geological investigation shows

* Corresponding author. E-mail: chaowendi@qq.com

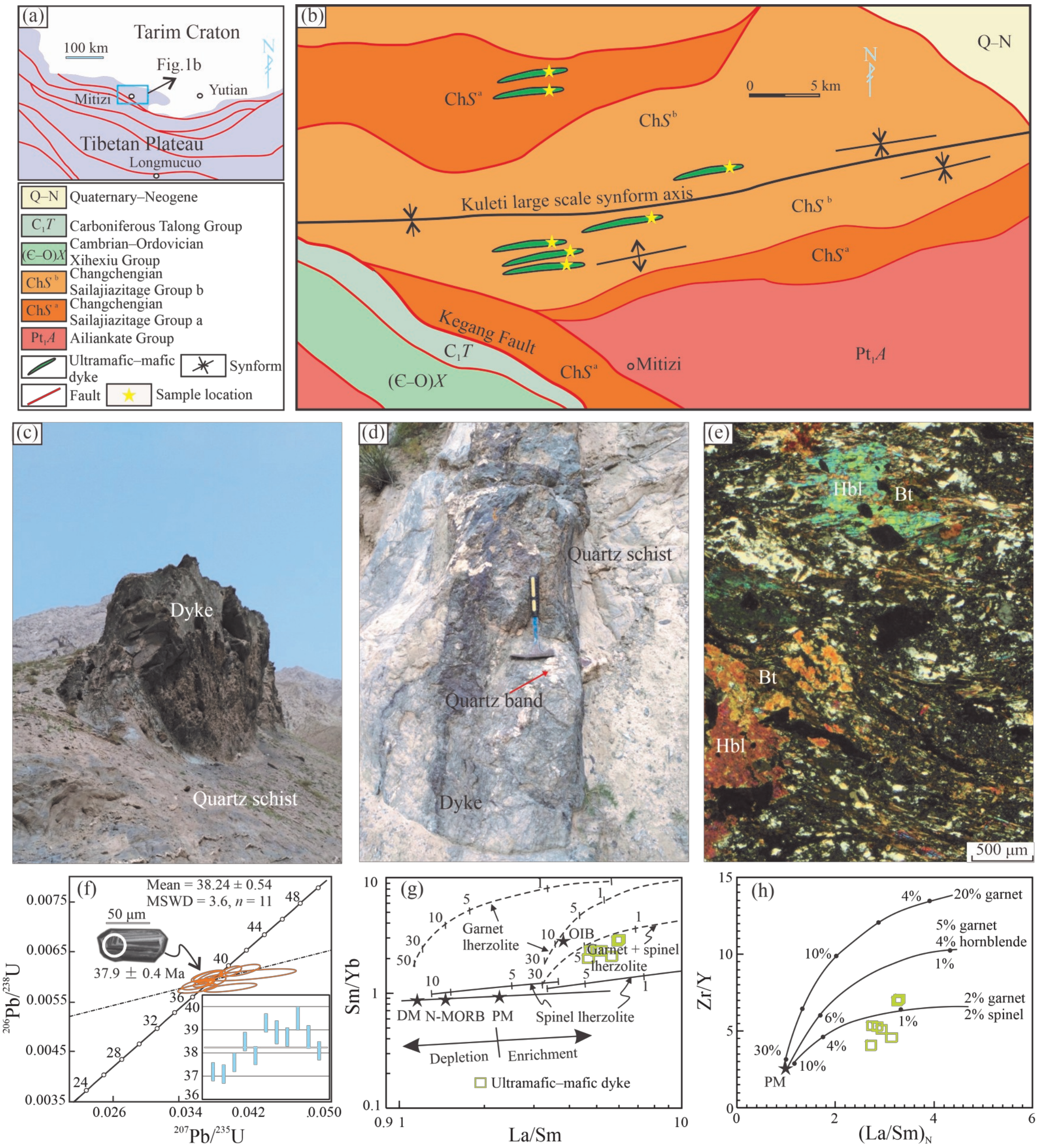

Fig. 1. (a) Simplified tectonic framework of the northwestern Tibetan Plateau; (b) sketch geological map of the Mitizi area; (c–d) field characteristics; and (e) microphotograph of the ultramafic–mafic dyke swarms; (f) zircon U-Pb ages of the dyke swarms; (g–h) Sm/Yb-La/Sm and Zr/Y-$(La/Sm)_N$ diagrams for the dyke swarms. Hbl, hornblende; Bt, biotite.

that these studied rocks are extensively distributed along with a series of large faults (Fig. 1a). Together with the regional geological characteristics, therefore, we suggest that a tectonic extensional regime related to 'large-scale strike-slip faults + mantle delamination' can account for the formation of these ca. 38 Ma dyke swarms in the northwestern Tibetan Plateau, further revealing that Cenozoic mantle activity might have played an important role in the tectonic uplift of the Tibetan Plateau.

Conclusions

Late Eocene (ca. 38 Ma) ultramafic–mafic dyke swarms have been identified for the first time in northwestern Tibetan. Geochemical data show that these dykes were derived from low-degree partial melting of a mantle source, and their formation was likely associated with an extension regime resulting in a combination model of 'large-scale strike-slip faults + mantle delamination'. This new discovery provides new insight for the study of the Cenozoic tectonic evolution of the Mitizi area, northwestern Tibetan Plateau.

Acknowledgments

This study is financially supported by Geological

Survey Projects of the Chinese Geological Survey (Grant No. DD20160003) and Fundamental Research Funds for the Central Universities, Chang'an University (Grant No. 300102279710).

Supplementary material to this article can be found online at http: //doi.org/10.1111/1755-6724.14745.

References

Luo, Z.H., Mo, X.X., Hou, Z.Q., Deng, W.M., Wang, J.H., Zhao, Z.D., Yu, X.H., and Li, J.P., 2006. An integrated model for the Cenozoic evolution of the Tibetan plateau: Constraints from igneous rocks. Earth Science Frontiers, 13(4): 196–211 (in Chinese with Engilish abstract).

Xu, Z.Q., Li, H.B., Tang, Z.M., Qi, X.X., Li, H.Q., and Cai, Z.H., 2011. The transformation of the terrain structures of the Tibet Plateau through large-scale strike-slip faults. Acta Petrologica Sinica, 27(11): 3157–3170 (in Chinese with English abstract).

Zhang, C.L., Lu, S.N., and Yu, H.F., 2007. Geological evolution of orogenic belt in northern Qinghai Tibet Plateau, West Kunlun, China, and evidence from zircon SHRIMP and LA-ICP-MS dating. Science in China (Series D, Earth sciences), 37(2): 145–154.

Zhao, J.H., and Zhou, M.F., 2007. Geochemistry of Neoproterozoic mafic intrusions in the Panzhihua district (Sichuan Province，SW China): Implications for subduction-related metasomatism in the upper mantle. Precambrian Research, 152: 27–47.

Zhu, D.C., Zhao, Z.D., Niu, Y., Dilek, Y., Wang, Q., Ji, W.H., Dong, G.C., Sui, Q.L., Liu, Y.S., Yuan, H.L., and Mo, X.X., 2012. Cambrian bimodal volcanism in the Lhasa terrane, southern Tibet: Record of an Early Paleozoic Andean-type magmatic arc in the Australian Proto-Tethyan margin. Chemical Geology, 328: 290–308.