Delineating the Source of Lead in the Urban Atmospheric Dust Fall Based on Stable Isotopic Ratio: A Case Study from Panzhihua City, Southwest China

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Objective

Atmospheric lead pollution is a global problem. Mining, coal mining, iron and steel smelting, and chemical and coal-fired power plants are major industries in Panzhihua City, Southwest China. Many toxic and harmful heavy metals, including Pb, are emitted in production activities. Pb seriously affects human health and natural ecosystems. Thus, Pb source tracing is important for Pb pollution control (Souto-Oliveira et al., 2018; Zhao et al., 2015). We carried out Pb isotopic compositions analyses of the lead sources in the atmospheric dust fall in Panzhihua City for the first time in order to provide the scientific basis for the prevention and control of atmospheric heavy metal pollution in Panzhihua City.

Methods

According to the pollution situation in Panzhihua City, 20 samples were collected from the industrial area, residential area, traffic area and end-members. All samples were packaged separately to avoid cross contamination. The samples in the laboratory passed through the 200-mesh nylon sieve and were weighed accurately. Trace element and high precision isotopic (Pb) measurements were carried out at Nanjing FocuMS Technology Co., Ltd. The instruments used include Agilent 7700x ICP-MS and Nu Plasma II MC-ICP-MS. The measurement errors of lead isotope ratios of all samples were within the allowable error range.

Results

Average Pb concentrations and isotopic signatures in atmospheric dust fall samples from Pan-

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This article has been accepted for publication and undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record. Please cite this article as doi: 10.1111/1755-6724.13842.

zhihua City are shown Table 1. The Pb concentrations of 13 samples ranged from 26.045 to 418.436 μg/g, average 236.324 μg/g, and were 8 times of the allowable standards stipulated in Background Values of Soil Elements in Sichuan, China (30.9μg/g). Isotopic fingerprints of atmospheric dust fall in Panzhihua City included $^{206}Pb/^{207}Pb$ ratios of 1.141 to 1.209 and $^{206}Pb/^{208}Pb$ ratios of 0.469 to 0.486. In contrast, Pb isotopic signatures of atmospheric dust fall from the industrial area were more radiogenic and included $^{206}Pb/^{207}Pb$ ratios of 1.174 to 1.180 and $^{206}Pb/^{208}Pb$ ratios of 0.477 to 0.478.

Table 1 Pb isotopic ratios in atmospheric dust fall samples from Panzhihua City

Samples	Pb concentration (μg/g)			$^{206}Pb/^{207}Pb$			$^{206}Pb/^{208}Pb$		
	Aver	Max	Min	Aver	Max	Min	Aver	Max	Min
Traffic area (n=4)	321.579	418.436	223.763	1.172	1.177	1.166	0.476	0.477	0.475
Residential area (n=5)	192.851	244.232	117.244	1.170	1.172	1.169	0.476	0.476	0.475
Industrial area (n=4)	205.410	266.733	146.951	1.177	1.180	1.174	0.478	0.478	0.477
Soil (n=3)	-	-	-	1.196	1.209	1.181	0.482	0.486	0.478
Motor vehicle exhaust dust (n=2)	-	-	-	1.156	1.171	1.141	0.472	0.475	0.469
Fly ash (from coal combustion) (n=1)	-	-	-	1.242	-	-	0.493	-	-
Smelting dust (n=1)	-	-	-	1.174	-	-	0.477	-	-

Most of the atmospheric dust fall samples from the industrial area, residential area and traffic area were closely related to smelting dust (Fig. 1), indicating that the smelting process was the main Pb source of the atmospheric dust fall samples. Smelting dust significantly affected the Pb isotopic composition of the atmospheric dust fall samples. Due to the heavy traffic in Panzhihua City, especially a large number of trucks, motor vehicle exhaust dust was another important source of lead. All atmospheric dust fall samples were far away from the fly ash (from coal combustion), indicating that Pb concentrations in the atmospheric dust fall samples were less influenced by coal combustion. Pb isotopic ratios of most soil samples were not close to those of the collected atmospheric dust fall samples, showing that soil was also not a significant contributor to the atmospheric dust fall in Panzhihua City.

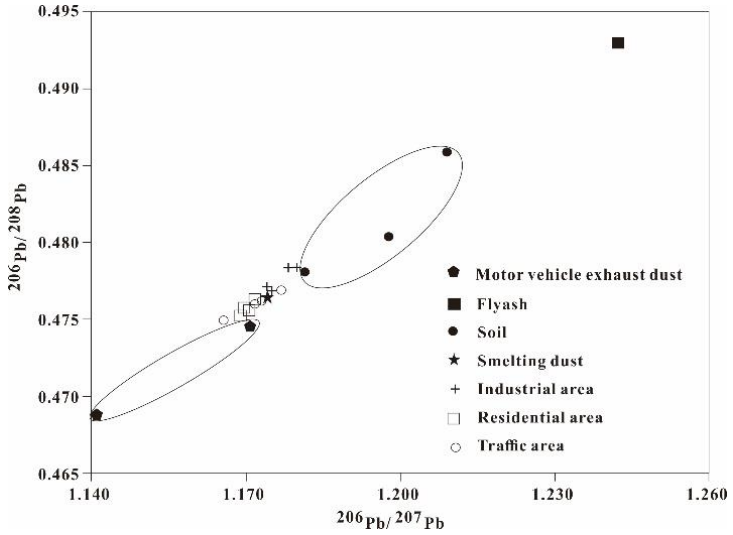

Fig. 1. Relationship between 206Pb/208Pb and 206Pb/207Pb in atmospheric dust fall from Panzhihua City.

Furthermore, the quantitative results of source contributions based on a ternary mixing source model were smelting (61.25%), motor vehicle exhaust (23.94%) and soil (14.81%). The contributions were supported by the atmospheric sampling sites which were near to a large smelter in Panzhihua City near and were in line with Pb isotopic analysis diagram (Fig. 1).

Conclusion

Atmospheric dust fall, soil, motor vehicle exhaust dust, fly ash and smelting dust samples from Panzhihua, Sichuan, were collected and analyzed for their lead isotopic compositions. The results showed that smelting dust was the main anthropogenic source of Pb in atmospheric dust fall, followed by motor vehicle exhaust emissions and soil. Fly ash had a minor effect on the atmospheric dust fall. Pb in Panzhihua mainly originated from smelting (61.25%), motor vehicle exhaust (23.94%) and soil (14.81%).

Acknowledgments

This research was financially supported by the National Natural Scientific Foundation of China (41673109), science and technology planning project of Sichuan Province (2017SZ0185) and Beijing Environment Foundation for Young Talents (BEFYT).

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