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Lead isotopic signatures of wine and vineyard soils—tracers of lead origin

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Abstract

The Pb contents and $^{206}Pb/^{207}Pb$ and $^{208}Pb/^{206}Pb$ isotopic ratios were studied in the soils and wines (2004 harvest) of three vineyard areas of the Czech Republic. The areas differ in their geological basements and anthropogenic loading. The isotopic compositions of wine in areas with intensive industry (Most, North Bohemia $^{206}Pb/^{207}Pb_{wine} = 1.178 \pm 0.004$) and the agricultural areas of Central Bohemia (Roudnice nad Labem $^{206}Pb/^{207}Pb_{wine} = 1.176 \pm 0.007$) are similar to the Pb isotopic composition of airborne particulate material typical of polluted and industrial environments ($^{206}Pb/^{207}Pb = 1.17–1.19$). The isotopic composition of wine from Prague ($^{206}Pb/^{207}Pb_{wine} = 1.174 \pm 0.003$) is different from that of the soil, which was severely contaminated in the past by vehicular Pb ($^{206}Pb/^{207}Pb_{soil} = 1.147–1.168$). This fact shows that interception of airborne Pb by plants is greater than its uptake by the root system.

Keywords: Wine; Vineyard soil; Lead isotope; Pollution; ICP-MS

1. Introduction

Lead is a nonessential element whose biogeochemical cycle is significantly affected by man (Nriagu, 1978). Estimates of lead emissions indicate that the atmosphere is the major initial recipient and that the contribution from anthropogenic sources is at least 1–2 orders of magnitude greater than that from natural sources.

$^{206}Pb/^{207}Pb$ and $^{208}Pb/^{206}Pb$ ratios are commonly used as tracers to differentiate natural and anthropogenic Pb (e.g., Monna et al., 1997; Ettler et al., 2004). In Central Europe, the lead isotopic signatures of pollution sources range from relatively high $^{206}Pb/^{207}Pb$ ratios (natural Pb, coals, fly ashes; $^{206}Pb/^{207}Pb = 1.17–1.22$) to low $^{206}Pb/^{207}Pb$ values (gasoline, petrol combustion; $^{206}Pb/^{207}Pb = 1.06–1.14$) (Ettler et al., 2004; Monna et al., 1997; Novák et al., 2003).

The total element content in wine has three major sources. The first is in the soil formed by weathering of the parent rock. Uptake by roots is still considered as the major pathway of metal incorporation into plant biomass (Lin et al., 1995). The second group of substances consists in compounds used in fertilizers, pes-

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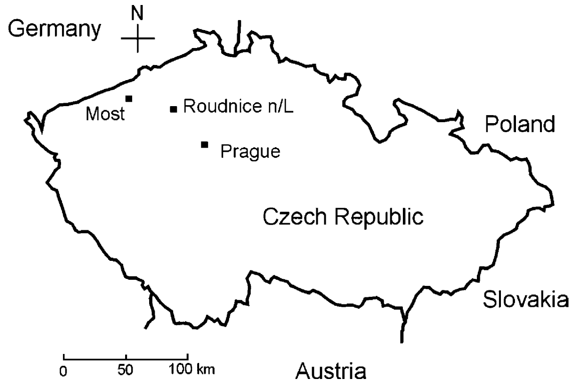

Fig. 1. Location of the studied vineyard areas.

ticides, food additives and substances released during food technology. The pollution of the environment is the third notable source of trace elements in wine. In this work, we attempted to determine the origin of lead in vineyard soils and wines from three vineyard areas in the Czech Republic, on the basis of isotopic composition and concentration.

2. Materials and methods

Samples were collected in vineyards in Prague, Roudnice nad Labem and Most (Fig. 1). While Prague is a city with dense traffic and Most is an area with heavy industry and brown coal mining, the vineyards around Roudnice nad Labem are located in an agricultural area. The Mělník coal-fuelled power plant is the only important source of pollution in this area. The sampling sites of studied vineyards are not tilled. The vineyard in Prague has no grass cover. While the upper soil horizon in Roudnice nad Labem is enriched in organic matter, both soil profiles in Prague and Most do not exhibit natural development of soil horizons.

The soil samples were dried to constant weight and sieved to 2 mm. An aliquot was finely ground in an agate mortar. Mineralization of soils and preparation of solutions for the determination of the total lead content are described in Ettler et al. (2004). The 24-h extract for the determination of the labile fraction of lead was prepared in 0.5 M HNO_3 at a solid/liquid ratio of 1:10. This weak acid extraction is supposed to liberate anthropogenic Pb from soils (Teutsch et al., 2001).

Wine samples from the 2004 harvest were stabilized by addition of HNO_3 (1 ml conc. HNO_3 per 50 ml of wine). Mineralization was carried out using HNO_3 and H_2O_2 in Savillex vessels heated to 150 °C. Details of the sample treatment and analyses of the wines are given in the work of Kment et al. (2005).

The isotopic ratios and Pb concentrations were determined using ICP-MS PQ 3 (VG Elemental, GB). Detailed analytical conditions are given in Ettler et al. (2004). Mass bias correction of measured isotopic ratios was performed using NIST SRM 981 (Common lead).

3. Results and discussion

The Pb contents in the individual soil profiles are shown in Fig. 2. The highest Pb contents were found in soils from Prague (Mean ± S.D. = 133 ± 47 mg/kg), fol-

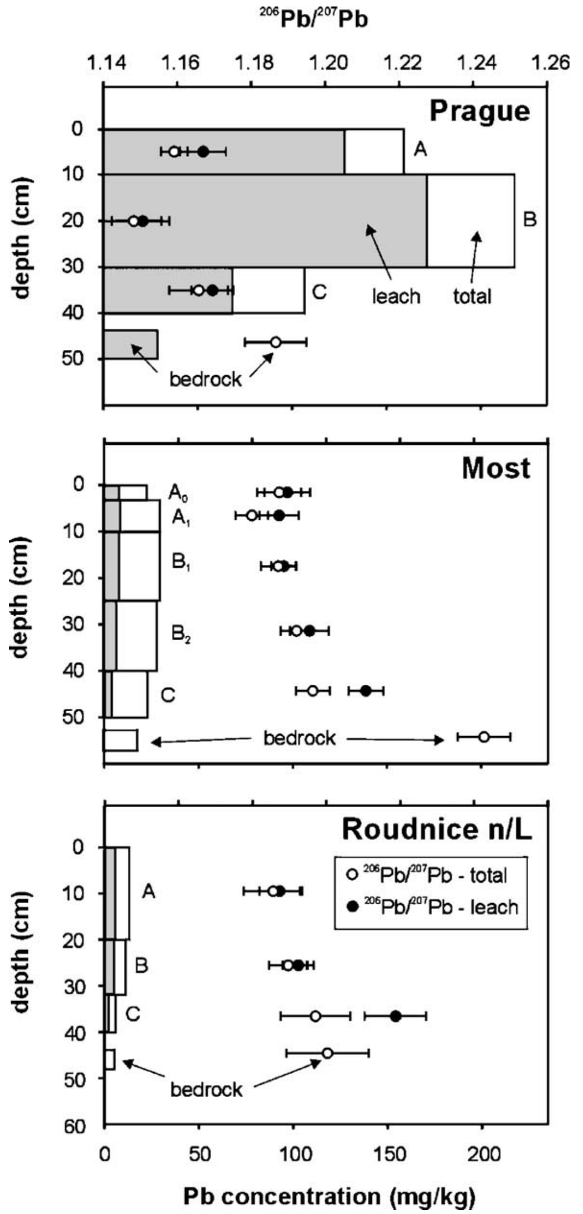

Fig. 2. Total Pb content, Pb content in the 0.5 M HNO_3 extract and the $^{206}Pb/^{207}Pb$ isotopic ratio in soils.