Impact of tire-derived fuel on the chemical composition of coal-combustion products

R. GIERÉ [1], L.E. CARLETON [1], S.T. LAFREE [1], A. ZINGG [1], AND J.K. TISHMACK [2]

[1] Earth & Atmospheric Sciences, Purdue University, West Lafayette, IN 47907-1397, USA (giere@purdue.edu)
[2] Building Services & Grounds, Purdue University, West Lafayette, IN 47907-1661 (jktishmack@purdue.edu)

Coal-fired power plants generate about 27% of the electricity consumed worldwide, and also produce large amounts of waste (ash) in addition to gaseous emissions. Several utility companies in the U.S. burn coal together with discarded automobile tires, and thus turn a major waste stream into an alternate fuel. Although this practice could lead to significant savings in coal consumption, the combustion of scrap tires may increase the concentration of some chemical elements in the coal-combustion products (CCP). To assess the chemical impact on the CCP and on the atmospheric emissions, the Purdue University power plant conducted an experiment with two different sets of fuel combusted at the same conditions (≈1500 ºC): pure coal and a mixture of 95 wt% coal plus 5 wt% tire-derived fuel (TDF). A detailed chemical comparison was made of both types of fuel and the resulting CCP.

Compared to pure coal (sub-bituminous coal from Southern Indiana), TDF is considerably richer in Zn (133±34 vs. 32±43 ppm), and also has a higher S content (1.76±0.91 vs. 0.57±0.55 wt%). The increase in Zn is due to the high Zn content of the scrap tire chips (10936±849 ppm). Most of the other 56 elements studied had similar concentrations in both fuel types. Coal contains approximately 10 wt% non-combustible mineral matter, and the combustion process leads to enrichment of many chemical components in the CCP. The levels of enrichment are different for different elements, (typically ranging between factors of 10 and >100), and also depend on the temperature at which the various ash types were collected. The bulk Zn concentrations in CCP derived from TDF, for example, are 238, 3850, and 61500 ppm in bottom ash, mechanical separator ash, and electrostatic precipitator ash, respectively. For ash derived from pure coal, these values are 68, 106, and 3450 ppm, respectively. The enrichment, however, depends also on the size of the ash particles, whereby elemental concentrations increase with decreasing size. The smallest size fraction studied (<38 µm) accounts for >25 wt% of the bulk fly ash and exhibits the highest concentrations of many trace elements (e.g., As, Cd, Cu, Pb, Sb, U, Zn). In this size fraction, the concentrations of these and several other elements are markedly higher than those in the bulk ash.

The experiment demonstrates that combustion of TDF may lead to a considerable increase in the Zn contents of CCP, particularly of the finest fly ash fraction, some of which is emitted as particulates into the atmosphere.

Progress in understanding magma chambers based on high-resolution phenocryst microprobe analysis

C. GINIBRE[1,2] AND G. WÖRNER[1]

- Abt. Geochemie, GZG, 37077 Göttingen, Goldschmidtstr. 1, Germany (gwoerne@gwdg.de)
[2] now at : Laboratoire de Planétologie et Géodynamique, 2, rue de la Houssinière, 44322 Nantes cedex 3 - France (catherine.ginibre@chimie.univ-nantes.fr)

Processes in magma chambers are recorded in igneous phenocrysts through major and trace element zoning. For two case studies, we combine high-resolution imaging methods (back scattered electrons) with quantitative microprobe analysis of major, minor and trace elements (Ba, Sr, Fe, Ti, Mg) in volcanic feldspars to constrain magma chamber evolution at high spatial and temporal resolution.

Tephra from the chemically zoned phonolitic Laacher See magma chamber (Germany) contains three different types of sanidine that record various growth environments: convecting main magma body, highly differentiated boundary layer (roof and walls), and movement from an early less differentiated crystallising boundary layer into the main magma body. The majority of these "phenocrysts" were not erupted in the magma in which they originally formed. Their complex inheritance rather indicates crystal dispersion and exchange between layers of the zoned magma. Trace element zoning in sanidine shows the increasing influence of a mafic magma in the convecting main magma body. In the presence of plagioclase, the ternary compositions of sanidine constrain a large temperature range from 700 °C at the wall of roof to 1000°C at the base of the magma chamber. This suggests a possible recharge and progressive mingling with a basanitic magma as heat source and driving force for convection.

The andesitic Parinacota volcano (Chile) "Old Cone" stage" is dominated by a long differentiation history with rare recharge events. This is seen in the Sr and Fe zoning patterns of large plagioclase phenocrysts, which are characterised by oscillatory major element zoning patterns and frequent dissolution surfaces, uncorrelated between crystals. This indicates a convecting environment in the main magma body. Smaller crystals with lower trace element content at variable An content record a larger influence of a wet differentiated crystallising boundary layer. A time scale and crystal residence time of less than a few thousand year for differentiation is given by the absence of Sr-diffusion in the core.

"Young Cone" Parinacota was built after a flank collapse in less than 18 ky. Its andesitic plagioclase phenocrysts show mutiple resorption. Trace element zoning indicate at least two correlated recharge events within many crystals, involving two different endmembers magmas. These are present in all eruptive stages of Parinacota volcano but recharge is at much higher frequency in the "Young Cone". Parinacota volcano is thus characterized by an increased frequency of recharge events after the catastrophic flank collapse.