

# SAMPLING AND ANALYSIS OF EMISSIONS DURING THE INTERNATIONAL CROWN FIRE MODELLING EXPERIMENT: A FOCUS ON THE CARBON COMPOSITION OF AEROSOLS

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## ABSTRACT

During each summer of 1997 through 2001, a series of experimental forest fires in Canada's Northwest Territories, collectively known as the International Crown Fire Modelling Experiment (ICFME), provided a unique opportunity to collect emissions that closely represent those of boreal wildfires, a major source of carbonaceous constituents in the global atmosphere. In 1998 and 2000, we sampled several fires for particulate carbon, as well as carbonaceous semi-volatile compounds and gases. Separate samples were collected for the flaming burn stage and the smoldering stage that follows. These samples were subsequently analyzed for organic carbon, black (elemental) carbon, and polycyclic aromatic hydrocarbons (PAHs) in an effort to chemically characterize this particular combustion source and its two burn stages.

Multiple platforms for collecting particles, semi-volatiles, and gases were used at ground level and in aircraft. During the 1998 ICFME, a high-volume virtual impactor (300 L/min) was used at ground level downwind to collect particles in two size modes: fine (<2.5 microns) and coarse (2.5–10 microns). Combustion sources produce mainly fine particles; however, these can agglomerate into particles classified as coarse. Both fine and coarse particles in smoke plumes above the burn plots were sampled by helicopter in 1998 using a ca. 400 L/min sampler. During the 2000 ICFME, a high-volume cascade impactor (ca. 1,200 L/min) was placed 3 m above ground downwind to separate particles into several size classes. Cascade impactors allow particles to impact one of several stages containing a filter mounted on a plate. Larger particles impact the filters at the first stages in the air stream. Smaller particles impact the filters at the later stages in the air stream. A second high-volume sampler alongside the cascade impactor was used to trap semi-volatiles from the fires such as PAHs on polyurethane foam and XAD2 resin. Concurrently at ground level, gas-phase emissions were collected in pressure-filled or in evacuated canisters. The smoke plumes above the burn plots were sampled in 2000 by fixed-wing aircraft using the wing-intake airflow diverted to a passive particle sampler or Tedlar bags for gases.

Particulate organic carbon and black carbon were measured by thermal–optical analysis on a series of quartz-fiber filters from the 1998 ICFME. Corrections were made for sampling artifacts due to the adsorption of gas-phase organic carbon on the filters as well as the loss of particulate carbon during sampling. The ratio of black carbon to total carbon was  $0.085 \pm 0.032$  for the flaming stage and  $0.0087 \pm 0.0046$  for the smoldering stage. Thus, the flaming stage produced 10 times more black carbon than the smoldering stage when normalized to total carbon.

Among individual PAHs measured from particles and normalized to benzo(e)pyrene, retene was by far the most abundant compound in both the flaming stage and smoldering stage. However, retene and dimethyl phenanthrenes were substantially higher for the smoldering stage than the flaming stage. Thus, distinctive PAH profiles exist for the two burn stages.

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