Uranium oxides generated from armored vehicles perforated by ammunition composed of depleted uranium metal

K.M. KRUPKA, M.A. PARKHURST, B. AREY AND E.D. JENSON

Pacific Northwest National Laboratory, Richland, WA (ken.krupka@pnl.gov; maryann.parkhurst@pnl.gov)

Munitions of armor-piercing depleted-uranium (DU) metal were used by the U.S. Department of Defense (DoD) on the battlefield for the first time during the 1991 Operation Desert Storm. Since then, they were used by NATO in the Balkan conflicts and by DoD in the recent 2003 Operation Iraqi Freedom. DU munitions that impact hard targets or are enveloped in fire undergo oxidation to form DU oxide particles and agglomerations. Spent DU penetrators on firing ranges or on battlefields also corrode in the natural evironment to yield DU oxides. In response to questions raised after the Gulf War about the health significance of exposure to DU, the U.S. Department of Defense initiated the Capstone DU Aerosol Study to quantify and characterize DU aerosols collected inside, on, and near to Abrams tanks and Bradley Fighting Vehicles struck by DU penetrators. XRD analysis determined that the aerosols were primarily a combination of U_3O_8 and UO_3 phases, though intermediate phases resembling U_4O_9 and other oxides were prominent in some samples. SEM analyses showed some large DU particles that appear to have fractured, perhaps as a result of abrasion and comminution. Others were spherical, occasionally with a dendritic or lobed surface structures. SEM/EDS analysis of the aerosols identified the presence of oxides of U, Al, and Fe, and lesser amounts of Cu, Zn, Ti, Si, Ca, and Mg. Other studies by PNNL and others show that oxidation of these aerosol products and of spent DU penetrators in the natural environment ultimately results in a mixture of metaschoepite and schoepite. With continued exposure to pore water in soils, the schoepite phases will likely continue to alter to less soluble U(VI) phases, such as becquerelite, uranophane, soddyite, autunite, and related U(VI) minerals. The results from the Capstone study provide additional data about aerosols generated by the impact of armored vehicles by DU munitions and an improved scientific basis for assessing health risks and environmental fate of DU fragments, aerosol and corrosion products in soil systems.

Mineral precipitation and corrosion in a long-term zero-valent iron reactive barrier

D.H. PHILLIPS[1], D.B. WATSON[2], B. GU[2], Y. ROH[2] AND S.K. CHOI[3]

[1]Civil Engineering Department and Environment Agency, Queen's University Belfast, BT9 5AG, Northern Ireland (dhphillips2003@yahoo.com)
[2]Environmental Sciences Division, Oak Ridge National Laboratory, PO Box 2008, Oak Ridge, TN 37831
[3]Department of Soil, Water and Environmental Sciences, The University of Arizona, Shantz Building 429, PO Box 21038, Tucson, AZ

Zero-valent iron (ZVI) permeable reactive barriers (PRB)s have been effective in the remediation of certain contaminants (i.e. uranium) from groundwater. However, long-term corrosion of ZVI filings and mineral precipitate accumulation may decrease the effectivenss of a ZVI PRB to mediate groundwater. Notable changes in mineral precipitates, cementation and corrosion of ZVI filings within the Oak Ridge Reservation Y-12 in-situ PRB have occurred afrer about 2.5 yrs of operation.

Discussion of Results

Iron (oxy)hydroxides, maghemite/magnetite and aragonite occurred throughout the PRB. Geothite, lepidocrocite, mackinawite, siderite, aragonite and calcite were associated with oxidized and cemented areas, while green rusts were present in reduced zones. Since an earlier study of this PRB after about 1.2 yrs of operation there were 1) increases in iron (oxy)hydroxides, and calcium and iron carbonate minerals, 2) increases in cementation, as shown in the figure below where the iron filings are cemented with calcium carbonate, and 3) increases in oxidation, corrosion, and disnitigration of ZVI filings, especially in cemented areas.

Conclusions

If the amount of corrosion and cementation that occurred from about 1.2 to 2.5 yrs after installation continues, certain araes of the PRB (i.e. up-gradient entrance of PRB to groundwater) may last less than 5 more years; thereby, decreasing the effectiveness of the PRB to mitigate contaminants.