## SESSION 198, 1:30 PM
## Thursday, October 31, 1996
## T28. MSA and Clay Mineral Society: Environmental Mineralogy - Part II
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### 1:30 PM Skelton, Robyn K.

WATER-DISPERSIBLE CLAY AND PARTICLE-MEDIATED TRANSPORT OF NON-POINT SOURCE POLLUTANTS IN THE NORTH BOSQUE RIVER WATERSHED, NORTH CENTRAL TEXAS

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Nonpoint-source (NPS) pollution is the principal cause of water quality problems in the United States. The movement of NPS contaminants can be facilitated through sorption to suspended particles mobilized during surface runoff events, a process known as particle-mediated transport. Particle-mediated transport is dependent upon two processes: the dispersal of particles and formation of stable suspensions and contaminant sorption to the suspended particle. The purpose of this study was to determine the physiochemical factors that control the dispersibility of soil particles and influence their ability to sorb contaminants.

Six soils were collected from field plots in the North Bosque River watershed. Sequential extraction of organic matter and Fe oxides on the water-dispersible clay fraction was done to examine the effects of mineralogy, surface coatings and organic matter content on particle dispersibility. Batch sorption/desorption experiments using model contaminants were carried out on these fractions.

Two types of soils dominate the study area: clay soils with high carbonate contents and sandy loams. The clay soils include the Houston Black, Purves-Dugout and Denton and develop over the Glen Rose Limestone and Walnut Shale. The sandy loam soils include the Windthorst and the Duffau and develop in upland areas over the Paluxy Sandstone. Water-dispersible clay content is highest in the clay soils (6.7 - 8.4% by mass). These soils also have the highest total clay content (44% - 58%) and the highest carbonate content (8% - 26%). The sandy loam soils have lower water-dispersible clay contents (2.1% - 4.8% by mass) and correspondingly lower total clay contents (14% - 22%) and carbonate contents (0% - 2%). Organic matter values for all six soils vary from 2.5% to 4.3% and show no apparent relationship with water-dispersible clay content of the soils.

### 1:45 PM Logsdon, Mark J.

PRE-MINING WATER QUALITY IN HISTORICALLY MINED AREAS: IRON BOGS AND FERRICRETES IN THE SAN JUAN MOUNTAINS, COLORADO

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Mining in the San Juan Mountains near Silverton CO for more than 100 years has left abandoned mines and mine wastes in headwaters of the Animas River. Regulatory agencies and others maintain that the historic mining near Silverton has adversely affected water quality in the Animas. Sunnyside Gold plan to close the Sunnyside Mine, and determination of pre-mining baseline conditions in the mineralized San Juans is critical to evaluating successful closure.

Geochemical analyses of active and ancient deposits of iron oxyhydroxides were undertaken to estimate water quality associated with streams and springs in Cement and Mineral Creek drainages. Active deposition of iron oxyhydroxides in iron bogs and as interstitial cement in active alluvium ("ferricrete") were identified, mapped, and sampled in areas that are affected by acid mine drainage and in undisturbed areas. Ancient iron bogs and ferricretes are stratified below recent surficial deposits, and they also are present in geomorphic surfaces that are stranded far above the current base level.

Based on geologic mapping and hydrologic evaluations, models for the development of the iron oxyhydroxide deposits were formulated. Geochemical evaluation included whole-rock x-ray fluorescence, x-ray diffraction, and SEM analyses of solids, and chemical analyses of waters from which the active deposits were forming. Comparison of the active and ancient deposits shows that mineral phases and depositional textures are the same, the hydrologic and geomorphic settings are identical, and the trace elements and their concentrations are indistinguishable. Thus, waters discharging to streams in the current, post-mining conditions cannot be distinguioshed in metal loading and precipitation of iron oxyhydroxides from pre-mining conditions that were due entirely to natural weathering of mineralized ground under the geomorphic and climatic conditions of the San Juan Mountains.

### 2:00 PM Tingle, Tracy N.

X-RAY ABSORPTION SPECTROSCOPY (EXAFS) OF ARSENIC SOLID SOLUTION IN PYRITE, CLIO MINE, MOTHER LODE GOLD DISTRICT, TUOLUMNE COUNTY

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The major source of arsenic in soils and tailings in the California foothills is arsenian pyrite associated with Mother Lode gold mineralization. Analyses of pyrites from several localities reveal 0.5-5 wt.% As, typical of epithermal gold deposits worldwide. As K-edge x-ray absorption spectroscopy shows that As substitutes for S in pyrite and is not present as sub-microscopic inclusions of arsenopyrite as previously thought.

Pyrite (2 wt.% As) was separated from an albite-chlorite schist (Clio Mine waste rock). EXAFS for arsenopyrite, lollingite, orpiment, and pyrite with As substituted for S were calculated ab initio. The measured spectrum resembles the pyrite model. However, the fits obtained with these models were unsatisfactory. Instead, the measured EXAFS was fit assuming the local structure and coordination numbers appropriate for pyrite and arsenopyrite but allowing interatomic distances to vary. Lollingite and orpiment were ruled out. Best-fits to the measured spectrum yield radial distances that match those for pyrite to within 2-3%. For arsenopyrite, the agreement is not as good. In particular, the first-shell As-S distance determined (2.20 A) cannot be reconciled with that in arsenopyrite (2.35 A). This distance is slightly higher than in pyrite (2.18 A), consistent with previous work indicating an increase in the pyrite cell-edge with increasing As content. Abundant arsenian pyrite in waste rock and tailings at the Clio Mine suggests that the arsenic in soils and sediments is derived from the irreversible oxidation and hydrolysis of pyrite.

### 2:15 PM Hale, Jeffrey R.

CHARACTERIZATION OF ARSENIC AND CHROMIUM PARTITIONING IN SOILS

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The characterization and fate of arsenic and chromium in soil, and subsequent decisions regarding site remediation, are commonly based on total concentrations and concentrations in leachate derived from the U. S. EPA Toxicity Characteristic Leaching Procedure (TCLP). These analyses provide information pertaining to both spatial distribution and maximum leaching potential. Evaluating partitioning characteristics of arsenic and chromium within the soil media by application of selective extraction laboratory procedures in conjunction with X-ray diffraction determination of soil mineralogy provides valuable additional information. Arsenic and chromium contaminated soils at a chemical manufacturing facility represent a case study for application of this approach. From 0 to 6 feet deep, the soils are characterized by mottled, yellowish brown, silt and clay with fine sand, grading downward into light yellowish brown, silty, micaceous, fine sand, dominated by small, gray, foliated, lithic fragments and muscovite. Total arsenic and chromium are concentrated in the upper silt and clay, but are more readily leached from the lower sandy soil, suggesting partitioning based on soil composition. Selective extraction data indicate that arsenic is primarily associated with iron hydroxides in both clayey and sandy soils. In soils with a significant clay component, chromium appears to partition equally between iron hydroxides and organic material. However in strictly sandy soils, chromium is primarily associated with pore water. These partitioning phenomena are attributed to soil composition, soil permeability, oxidizing conditions, and the degree of sample contamination.

### 2:30 PM Boulet, Michelle P.

A MINERALOGICAL AND GEOCHEMICAL STUDY OF THE CLEVELAND MINE-TAILINGS IN NEW MEXICO, U.S.A.

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A study of sulfide mine-tailings at Cleveland mine site near Silver City in southwest New Mexico has shown the need for environmental monitoring in a geological context. The Cleveland orebody comprises dominantly skarn with minor replacement and vein mineralization in the Pinos Altos Mountains of New Mexico. Primary ore minerals include chalcopyrite, galena and sphalerite. The Cleveland Mine was in operation from 1915 to 1950, at which time it was closed and the site was abandoned. The Cleveland Mine (CMT) tailings were deposited in a canyon over an ephemeral spring. They are highly oxidized and differentially cemented. They have undergone many wet/dry cycles resulting in the formation of desiccation cracks in precipitates on the surfaces of grains. Secondary minerals dominate and consist mainly of goethite, jarosite, Fe-bearing gypsum, and amorphous iron oxyhydroxides and oxyhydroxysulphates. Tertiary minerals identified include gypsum and melanterite (hydrous Fe sulphate). The Cleveland site has been declared Superfund site by the U.S. EPA due to the occurrence of high concentrations of arsenic (276 ppm) in the tailings. These high arsenic concentrations may be a result of As- employing processing methods used for ore extraction, since no significant amounts of As- bearing minerals have not been observed in the ore or tailings themselves. An ephemeral stream drains the tailings into Little Walnut Creek. The pH of the stream water immediately below the CMT is 2.15. Maximum metal contents in the stream are 5305 ppm Zn, 454 ppm Cu, 1.16 ppm Pb, 17.5 ppm Cd, 1.4 ppm As, and 0.01 ppm Hg. The dissolved metal concentrations in the water dropped below detection limits at the confluence of the stream and the Little Walnut Creek where the pH increased to neutral.

### 2:45 PM Randall, Simon R.

CADMIUM ADSORPTION ON HYDROUS IRON OXIDES: AN EXAFS INVESTIGATION OF THE MECHANISMS.

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We have performed an EXAFS study to elucidate the structure of cadmium surface complexes on the iron oxyhydroxide polymorphs goethite (alpha-FeOOH), lepidocrocite (gamma-FeOOH), and akaganeite (beta-FeOOH), as well as schwertmannite (Fe8O8(OH)6SO4). The mechanism of cadmium sorption on iron oxyhydroxides is strongly pH-dependent: At intermediate pH (6-7.5), a surface precipitate is not detected and cadmium adsorbs by inner-sphere complex formation at the surfaces of goethite, lepidocrocite, and schwertmannite. Changes in the characteristic Cd-Fe separations with pH suggest that this complex formation is achieved by vertex-sharing (between the octahedrally solvated Cd2+ aquo ion and the neighbouring iron octahedra) on the goethite surface at pH 6.5. This changes to a corner-sharing mechanism at higher pH (7.4).

There is edge-sharing between cadmium and iron octahedra at the surface of schwertmannite at pH 6.5, and a combination of edge- and corner-sharing mechanisms on lepidocrocite at pH 6.0. At high cadmium concentrations (900 ppm) and high pH (pH 8), cadmium is removed from solution by the precipitation of Cd(OH)2 onto akaganeite. At very low pH there is negligible adsorption of cadmium to this mineral.