

The $\delta^{18}\text{O}$ values of the Mt. MaRac Formation (5 samples) and of the Jeerinah Formation (6 samples) fall in the same range, from +15 to +18‰ (SMOW). The lower $\delta^{18}\text{O}$ values are generally in rocks of higher K_2O contents; such a correlation has also been recognized in the footwall rocks of some volcanogenic massive sulfide deposits (VMSDs). The Mt. MaRac Shale is characterized by very high contents of organic carbon (up to ~10 wt.%) and sulfur, where the sulfur occurs as: (1) fine-grained disseminated sulfide minerals (mostly pyrite), (2) organic sulfur, and (3) pyrite nodules (up to ~1 m in diameter). The sulfur contents in the shales of (1) and (2) are typically in the range of 1 to 5 wt.%; the organic sulfur contents often exceed sulfide-sulfur contents; a positive correlation exists between the total sulfur and organic carbon contents. The $\delta^{34}\text{S}$ values of disseminated sulfides (and organic sulfur), as determined by in situ laser-probe isotopic analyses, vary about 5‰ (from -2.1 to +3.1‰ with an average of +0.9‰) among 13 spots within a small (~2 x 2 cm) area of a hand specimen. In contrast, a large pyrite nodule is found to be isotopically very homogeneous, with the $\delta^{34}\text{S}$ values of 1.0±0.5‰ for 6 spots in an area of ~5 cm in diameter; these $\delta^{34}\text{S}$ values are essentially identical to the average $\delta^{34}\text{S}$ value of the disseminated sulfides (and organic sulfur). These chemical and isotopic data suggest that the disseminated sulfides (and organic sulfur) formed by bacterial reduction of seawater sulfate ($\delta^{34}\text{S}_{\text{SO}_4} = \text{ca. } +3\text{‰}$) with a kinetic isotope effect of about 5‰, the pyrite nodules formed by remobilization of the disseminated sulfide sulfur by Fe-bearing hydrothermal fluids.

The pyrite nodules in the Mt. MaRac Formation are always rimmed by thin layers of silica of varying crystallinity. Fluid inclusions in quartz crystals rimming a pyrite nodule show homogenization temperatures ranging from 120 to 250°C for 23 inclusions. This provides the strongest evidence that high temperature hydrothermal fluids that formed the banded iron formation were discharged through the underlying shale units, rather than moved as plumes over several hundred kilometers from the mid oceanic ridges. The isotopic and fluid inclusion data obtained in this study support the model proposed by Ohmoto et al. (1992) that the geologic setting and the mechanism of mineralization for the banded iron formations in the Hamersley Basin were similar to the present-day Red Sea mineralization.

01:45 p.m. Smith, Leta K.

CATION GEOTHERMOMETRY IN OIL FIELD WATERS

SMITH, Leta K., DUNN, Thomas L., and SURDAM, Ronald C., Dept. of Geology & Geophysics, University of Wyoming, P.O. Box 3006, Laramie, WY 82071

The assumptions used in the development of cation ratio geothermometers (such as Na/K, Na-K-Ca, and Mg/Li) are: (1) the ratios of the cations are controlled by cation exchange between solid silicate phases, (2) aluminum is conserved in the solid phases, and (3) neither hydrogen ions nor CO_2 enter into the net reactions. These assumptions do not apply to oilfield waters where organic species are present and commonly abundant.

Nine different published cation geothermometers of Na/K, Na-K-Ca, Na-K-Ca-Mg, and Mg/Li were applied to 309 water samples from both oilfield and geothermal wells. Both data sets include waters from carbonate-bearing siliciclastic rocks. None of the cation geothermometers predicted consistent or accurate temperatures for the oilfield waters. Plots of measured v. predicted temperature for oilfield water samples gave correlation coefficients of less than 0.35. In contrast, those same plots of measured v. predicted temperature for geothermal water samples within the same temperature range gave correlation coefficients between 0.45 and 0.95. This analysis suggests that the presence of organic species, which is the difference between the two data sets, exerts a strong control on the cation ratios.

Organic species form complexes of varying stability with the cations. This, in turn, changes the relative concentrations of the cations in solution over that which is expected when cation exchange between silicate phases controls the ratios. Organic complexes also strongly affect pH and P_{CO_2} . The buffering capacity of the organic complexes in the 80-120°C temperature range strongly affects the solubility of the carbonate minerals. That in turn affects the Ca^{2+} in solution and thus the temperature predicted by the Na-K-Ca geothermometers.

Future development of an empirical cation geothermometer for oilfield waters must accommodate the presence of organic species and their control on various mineral solubilities.

02:00 p.m. Lyons, Timothy W.

WATER-COLUMN PYRITE FORMATION IN THE MODERN BLACK SEA: SULFUR ISOTOPIC CONSTRAINTS.

LYONS, Timothy W., Dept. of Geological Sciences, University of Michigan, 1006 C.C. Little Building, Ann Arbor, MI 48109; MURAMOTO, J., Dept. of Geology and Geophysics, Woods Hole Oceanographic Institution, Woods Hole, MA 02543.

Box-core and sediment-trap samples collected from the deep anoxic regions of the modern Black Sea (≥ 1000 m) have been analyzed for solid-phase sulfur concentrations and isotopic compositions and contrasted with available data for dissolved sulfide of the water column. Collectively, these data indicate quantitatively significant water-column production of iron sulfide. Upper Holocene, non-turbiditic deposits of the abyssal Black Sea are characterized by microlaminated, coccolith-rich sediments (Unit 1) with average pyrite-sulfur concentrations of 1.3 weight percent. Pyrite formation in Unit 1 is strongly limited by the availability of reactive iron phases. This conclusion is supported by the *degrees-of-pyritization* determined for these sediments (DOP—a measure of the extent to which original potentially reactive Fe has been transformed to pyrite). Additionally, down-core DOP trends for Unit 1 reveal that most pyrite formation occurred within the sulfidic water column and/or very close to the sediment-water interface (with an indication of only a 10 to 20% increase in pyrite content during burial). Flux determinations were performed for particulate reduced sulfur (pyrite + "FeS" + elemental S) using time-series sediment traps. The concentrations of particulate sulfur in trap samples, when compared with levels of Unit 1 pyrite, are consistent with a predominance of Fe-sulfide precipitation in the anoxic water column.

A subtle enrichment in ^{34}S has been described for the water-column dissolved sulfide of the chemocline region relative to the comparatively uniform isotopic composition of the sulfide reservoir below this narrow interface zone. This shift can be attributed to a diminished kinetic isotope effect in response to elevated rates of bacterial sulfate reduction in the vicinity of the oxic-anoxic interface and, perhaps, fractionations occurring during chemical oxidation of hydrogen sulfide. Particulate reduced sulfur collected from sediment traps deployed at a depth of 1000 m and Unit 1 pyrite (with relatively invariant down-core sulfur

isotopic compositions and mean $\delta^{34}\text{S}$ values [relative to CDT] of -37.0 and -37.3 per mil in two deep-basin cores) are both isotopically similar to dissolved sulfide of the chemocline region, but consistently display measurable isotopic differences with respect to the ambient dissolved sulfide of the deeper waters (with a narrow range of $\delta^{34}\text{S}$ values and a mean of -40.2 per mil). These isotopic relations suggest that water-column pyrite formation is quantitatively dominant and reveal that the production of pyrite in the deep basin (as recorded in the microlaminated sediment of the abyssal floor) is largely controlled by processes occurring within the immediate vicinity of the oxic-anoxic interface.

02:15 p.m. Brüchert, Volker

THE SHOAL ARM FORMATION, NORTH-CENTRAL NEWFOUNDLAND: FE- AND Mn-ENRICHED SEDIMENTS UNDERLYING BLACK SHALES AND FLYSCH BRÜCHERT, Volker, DELANO, John W., KIDD, William S.F., Department of Geological Sciences, State University of New York at Albany, Albany, NY 12222.

The Middle Ordovician Shoal Arm Formation is located in the central volcanic belt of north-central Newfoundland and consists of a sequence of hematitic argillites overlain by grey cherts and then black shales directly underneath a late Ordovician/early Silurian flysch sequence. The hematitic argillites are enriched in Fe, Mn, Ni, Pb, and Co. Geochemically definable components within related lithologic groups were discriminated using principal component analysis and factor analysis. These procedures indicate the presence of (1) biogenic, (2) mixed detrital, (3) hydrothermal, and (4) Mn-carbonate components. The close sampling of the whole 350-meter thick sequence provides the opportunity to reconstruct variations among the sediment components through time. The base of the hematitic part is marked by a sharp increase in the hydrothermal component, which then decreases stratigraphically upward. The Mn-carbonate component also decreases upwards, but persists up to the grey cherts. The clastic component changes from mixed mafic/pelagic clay-like detritus to Zr-, Nb-, and Y-rich detritus in the top hematitic part. This component is presumably derived from erosion of lateral equivalents of the alkaline/subalkaline Lawrence Head volcanics. The grey cherts mark a transitional stage between the hematitic sediments (oxic) and the black shales (anoxic). The change to increasingly O_2 -deficient conditions is explained by (a) an increase of biological productivity and related O_2 -drain by C_{org} -oxidation and/or (b) diachronous subsidence of the basin floor into a deep-water anoxic layer as a result of the loading of the basin floor by an approaching thrust stack. The anoxic water layer permitted lateral transport of recycled dissolved Mn, which was then subsequently oxidized and precipitated in more oxygenated parts of the basin.

The similar stratigraphic sequence and geochemistry of the Middle Ordovician sediments in the Taconic Allochthon of New York State suggest that these processes also acted at other locations along the continental margin of the Iapetus Ocean. This uniformity may reflect the strong influence of the warm Middle Ordovician climate on the sediment facies or, alternatively, the control by the specific tectonic environment.

02:30 p.m. Zaback, Doreen A.

CLARIFICATION OF C-S RELATIONSHIPS OF MARINE BLACK SHALES USING STABLE ISOTOPIC COMPOSITION OF REDUCED SULFUR.

ZABACK, Doreen A. and PRATT, Lisa M., Department of Geological Sciences, Indiana University, Bloomington, IN 47405.

Carbon-sulfur relationships are compared for the Miocene Monterey Formation (Santa Maria Basin, California) and the Upper Devonian New Albany Shale (Illinois Basin, Indiana). In both formations, C-S concentrations covary for samples with the lower to more intermediate organic carbon concentrations and become invariant at higher organic carbon concentrations. While the similarity of these relationships in Monterey and New Albany suggest sulfur diagenesis occurred in similar depositional environments, sulfur isotopic data clearly indicate differences in the depositional environments. In the Monterey, the most organic-rich laminated shales are characterized by isotopic enrichment of reduced S and low $S_{\text{reduced}}/C_{\text{org}}$ ratios and indicate that sulfate reduction occurred under sulfate-limited conditions within the sediments. In the New Albany, organic-rich laminated shales exhibit isotopic depletion of reduced S coupled with low $S_{\text{reduced}}/C_{\text{org}}$ and suggest sulfur diagenesis occurred under euxinic conditions.

These data show that in the absence of sulfur isotopic data, misleading conclusions concerning depositional environments can be made when using C-S plots and the traditional interpretations that are associated with these types of plots.

02:45 p.m. Kirby, Carl S.

AQUEOUS ALTERATION OF MUNICIPAL SOLID WASTE ASH

KIRBY, Carl S. and RIMSTIDT, J. Donald, Department of Geological Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061

Municipal solid waste (MSW) ash is composed largely of amorphous oxides and approximately 20% minerals including halite, magnetite, hematite, quartz, gypsum, calcite, and rutile. It is also enriched in toxic trace metals by up to three orders of magnitude over average soil. The thermodynamic stabilities and rates of dissolution of the minerals and glasses in MSW ash will determine whether the ash is an environmental problem.

We have used batch reactors at 20°, 40°, and 60°C over time periods up to 60 days to simulate longer reaction times for ash under cooler landfill conditions. Soluble salts are most quickly dissolved, giving solutions dominated by Ca^{2+} , Na^+ , K^+ ,

02:25 p.m. Hopkins, Isabella**PRESERVATION AND USAGE OF GEOSCIENCE IMAGERY IN THE U.S. GEOLOGICAL SURVEY FIELD RECORDS AND PHOTOGRAPHIC LIBRARIES 1879 TO DATE**

HOPKINS, Isabella, Special Collections; EDWARDS, Carol, Field Records Lib.; MACDONALD, Chloe & MCGREGOR, Joseph, Photographic Lib., U.S. Geological Survey Library, Box 25046, Denver Federal Center, MS914, Denver, CO 80225-0046.

We propose to establish the multiple values of preserving and organizing geoscience imagery for continued scientific and multi-disciplinary research. The Field Records and Photographic Libraries provide access to and preservation of 120 years of deposited field and photographic records created or collected in the process of U.S. Geological Survey operations.

Usage records kept since 1954 demonstrate the multiple values of geoscience imagery for continuing scientific and multi-disciplinary research. Imagery provides unique information, especially uninterpreted photographic observation documenting sites, events, and specimens. Evidential and comparison applications demonstrate economic, educational, historical, political, and social impacts.

The libraries' collections of geoscience imagery include drawings, annotated maps and aerial photographs, illustrated field notes, black and white photographic materials, and color media. In preserving geoscience imagery, material identification and deposit, preservation needs and costs, and material organization and description are the archival challenges. A prototype CD-ROM of black and white and color photography is explored as a next step in preservation, collection access, and distribution.

02:50 p.m. Clancy, Elizabeth H.**PRACTICAL PROCEDURES FOR PRESERVING PHOTOGRAPHIC POTPOURRI.**

CLANCY, Elizabeth H., Photo Archives, Denver Museum of Natural History, 2001 Colorado Blvd., Denver, CO 80205.

Photographs taken in the course of your work are as important to the documentation of that work as the written report itself. As long as photographs survive and are made available, they allow the viewer to actually "see" those things which no vocabulary can ever adequately describe. Photographs can provide an overview of the entire landscape as well as aspects of specific geological features. Specimens may be "seen" in matrix or in minute closeups which disclose structure or basic composition. Photographs can also vividly illustrate problems or successes in the field or laboratory. They visually record assistants; how they looked, what they did, and countless other details that in retrospect add dimension and perspective to your work. In other words, photographs are much more than personal mementos. They can, and should, be regarded as historical documents worthy of the best care you can give them to insure not only preservation of the physical artifact, but also preservation of the information contained within the image.

The proper organization and care of photographic collections require careful thought coupled with a moderate expenditure of cash and time. This paper addresses the basics of how to organize, document and store photographs. There will also be consideration of supplies, equipment, proper storage facilities and conditions. It will also touch on reasons why photographs don't last, which ones last longest, color vs. b&w, still photos vs. movies vs. video, and some of the many ways your photographs can be put to use.

What to photograph, how to photograph, and/or which kind of camera or camera equipment to use is not within the scope of this paper.

03:15 p.m. Golden, Julia**THE CALVIN COLLECTION: AN UNDEVELOPED RESOURCE.**

GOLDEN, Julia, Department of Geology, University of Iowa, Iowa City, IA 52242-1379.

Photographers have accompanied geological surveys since the mid-1800's. As photographic methods were simplified, photography became a popular hobby and a natural tool for scientists. Samuel Calvin, Professor of Natural Sciences at the University of Iowa (1873-1911) and State Geologist, took more than one thousand glass plate negatives which he used to illustrate specific geological features for class instruction, public lectures and publications. The photographic techniques are of high quality and the images are as aesthetically pleasing as they are geologically informative. The Calvin Photograph Collection is not unique; many academic departments probably house similar collections with similar characteristics.

As a bicentennial project, the Calvin Collection was inventoried, prints were made, and the plates were transferred to acid-free sleeves. A conservation assessment was not made at that time and funds to carry out an assessment are not forthcoming. However, excellent prints can still be made from most of the plates.

Most frequently, the photographs are referred to for their novelty rather than their research value.

To make the collection a more accessible and useful research tool, the information from the hand-written card index is being transferred to a database that will be available via a campus network. To help preserve the negatives, collection management documents for use, care and storage have been written, and access is restricted. For now, the Department of Geology is committed to retaining the Calvin Collection as a whole. However, as demands for space increase and budgets decrease, the safety of the collection is not assured and a permanent repository will be sought.

04:20 p.m. Fusonie, Alan**OUR AGRICULTURAL LANDSCAPE: IMPROVING IMAGE PRESERVATION AND END-USER IMAGE ACCESS THROUGH LASER DISK TECHNOLOGY.**

FUSONIE, Alan, National Agricultural Library, Beltsville, MD 20705; YOUNG, Ronald, National Agricultural Library, Beltsville, MD 20705; Richard Myers, National Archives, Special Collections, National Agricultural Library, USDA, Room 1402, Beltsville, MD 20705

A creative revolution in image preservation and end-user access to valuable historical images is under way. As the 1990's begin, optical laser disk technology is changing the way images (photographs, slides, artworks, and other unique and rare historical records) are stored, preserved, retrieved, distributed, utilized, and displayed. Providing access to and preserving the collections entrusted to its care are dual responsibilities of a research institution. Photo reference staffs at large research institutions and researchers seeking access to the holdings of these institutions are finding that laser disk systems improve access to collections of imagery. Curators, librarians, and archivists are finding that laser disk systems enhance significantly their preservation efforts through reduced physical handling of original materials by their staffs and patrons and improve overall administration of their holdings. Such benefits are particularly evident at the National Agricultural Library, where innovative laser disk system applications to the broad landscape of agricultural imagery generated by the U.S. Department of Agriculture are ongoing. The success of this program and its future enhancements will have a far-reaching impact on the preservation and dissemination of agriculturally related imagery and, by extension, will serve as a model for other research institutions worldwide.

04:50 p.m. Wallace, Jim**ELECTRONIC IMAGING IN A COMPREHENSIVE PROGRAM OF PHOTOGRAPHIC PRESERVATION**

WALLACE, Jim, Director/Curator, Office of Printing & Photographic Services, Smithsonian Institution, Washington, D.C.

The various forms of electronic imaging which have recently become commercially available have the potential to provide dramatic new opportunities to distribute photographic images held by museums and archives. The use of such alternative distribution means should be an integral part of an overall photographic preservation program. If adopted as part of an overall program of image preservation, electronic imaging can play a dynamic new role for holders of photographic archives. The technology will enable them to maintain the archival integrity of their original photographs, while simultaneously increasing and facilitating their distribution, availability and use.

SESSION 65, 1:30 p.m.**TUESDAY, OCTOBER 27, 1992****GS—GEOCHEMISTRY, OTHER I: FLUIDS, CLAYS, AND WEATHERING****CCC: 300-301****01:30 p.m. Haruna, Makoto****FLUID INCLUSION AND ISOTOPIC EVIDENCE FOR THE HYDROTHERMAL ORIGIN OF THE BANDED IRON FORMATIONS IN THE HAMERSLEY BASIN, WESTERN AUSTRALIA**

HARUNA, Makoto, KAKEGAWA, Takeshi, and OHMOTO, Hiroshi

Department of Geosciences, The Pennsylvania State University, University Park, PA 16802, USA.

Ohmoto et al. (V.M. Goldschmidt Conference, 1992) has presented mineralogical and chemical data on the shale units (the Mt. McRae and the Jeerinah Formations of ~2.5 Ga in age) that underlie the major banded iron formations in the Hamersley Basin, Western Australia. We report here data of oxygen and sulfur isotopic compositions and fluid inclusion filling temperatures on some samples of the Mt. McRae and the Jeerinah Formations.

TUE
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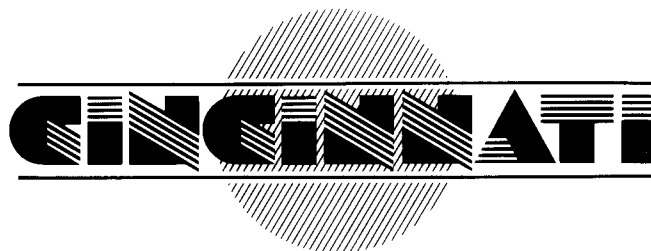


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**ABSTRACTS
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