VOLCANICALLY DERIVED CLAYS

Tuesday June 22, 2004

Volcanically Derived Clays Poster Session	
5:00p	**A REVIEW OF THE FRICTIONAL STRENGTH OF MONTMORILLONITE.** Diane E. Moore* and David A. Lockner U. S. Geological Survey, Mail Stop 977345, Middlefield Road, Menlo Park, CA 94025
	HIGH-RESOLUTION CHEMOSTRATIGRAPHIC CORRELATION OF THE LOWER SILURIAN (LLANDOVERY) OSMUNDBERG K-BENTONITE IN BALTOSCANDIA AND NORTHERN EUROPE. Funda O. Toprak*, and Warren D. Huff University of Cincinnati, Department of Geology, Cincinnati, OH 45221

Wednesday June 23, 2004

Volcanically Derived Clays	
4:20 – 4:40p	**SULFUR ISOTOPE AND POTASSIUM-ARGON ANALYSIS OF MINERALS FROM THE TURPLU HALLOYSITE MINE, BALISIKER REGION, NORTHWEST TURKEY.** Paul A. Schroeder*[1], Michael J. Smilley[1], Ö. Isik Ece[2], and Marion Wampler[3] [1]Department of Geology, University of Georgia, Athens, GA 30602-2501 USA schroe@uga.edu [2]Istanbul Technical University, Department of Geological Sciences, Maslak, 80626, Istanbul, Turkey. [3]School of Earth and Atmospheric Sciences, Georgia Institute of Technology, Atlanta, Georgia 30332-0340
4:40 – 5:00p	**BIOTITE AS A DISCRIMINATOR IN THE LATE ORDOVICIAN DEICKE, MILLBRIG AND KINNEKULLE K-BENTONITES.** Warren D. Huff*[1], Elif Muftuoglu[2], Stig M. Bergström[3], and Dennis R. Kolata[4] [1]Department of Geology, University of Cincinnati, Cincinnati, OH 45221, [2]Ugur Mumcu Cad. Ugur, Mumcu'nun Sok. 42/1 GOP, Ankara 06700, Turkey, [3]Department of Geological Sciences, The Ohio State University, 155 S. Oval Mall, Columbus, OH 43210, [4]Illinois State Geological Survey, 615 East Peabody Drive, Champaign, IL 61820

TUESDAY JUNE 22, 2004

VOLCANICALLY DERIVED CLAYS

POSTER SESSION

5:00PM

A REVIEW OF THE FRICTIONAL STRENGTH OF MONTMORILLONITE

Diane E. Moore* and David A. Lockner

U. S. Geological Survey, Mail Stop 977345, Middlefield Road, Menlo Park, CA 94025

Montmorillonite is a common constituent of the accretionary wedges and downgoing sediments of subduction zones, and it has also been identified in core samples from drillholes into active strike-slip fault zones. Knowledge of the frictional properties of montmorillonite may be critical to understanding the behavior of such faults. Unfortunately, many of the published data on montmorillonite friction are contradictory, with reported values of the coefficient of friction, μ (= shear stress/effective normal stress) ranging from 0.06 to 0.78. We propose that this wide variation is partly a function of the large difference in strength between thoroughly dried ($\mu \geq 0.7$) and water-saturated ($\mu \leq 0.3$) montmorillonite. Petrographic examinations indicate that dry montmorillonite gouge undergoes frictional processes such as abrasion, wear, and fracture during shear. In contrast, shear of water-saturated montmorillonite gouge is concentrated in thin films of water that are adsorbed onto the (001) surfaces of the platy grains. Our recent laboratory investigations suggest that water-saturated shear strength of layer-structure minerals increases with the strength of the bonding of the polar water molecules to the (001) surfaces, and the relative weakness of water-saturated montmorillonite may be largely owing to its small layer charge. Published values of μ for montmorillonite under (deionized) water-saturated, equilibrated conditions increase regularly from 0.06 at effective normal stresses <1 MPa to 0.30 at ≈300 MPa. The direct correlation of μ with effective normal stress is characteristic of sheet-silicate gouges, and it is attributed to decreasing thickness of the surface water films with increasing normal load. In contrast, μ of common framework silicates such as quartz exhibits little pressure sensitivity below about 200 MPa effective normal stress and then decreases with further increases in effective normal stress (Byerlee's law). Increasing salinity of the pore fluid has the same effect on the shear strength of montmorillonite as increasing effective normal stress, due to reduction in double-layer thickness of adsorbed water. Most of the published strength data for montmorillonite fall outside the trend of water-saturated, equilibrated samples on a plot of μ versus effective normal stress. The data that are stronger than the water-saturated results for a given set of experimental conditions may have been only partially saturated, whereas those that are weaker appear to be caused by inadequate drainage and consequent build-up of excess internal pore pressure that was not alleviated over the duration of the experiments. These results highlight the hazards of interpreting fault-zone behavior based on experiments that do not represent natural conditions. For example, the use of unsaturated clay rheology in modeling subducted sediment wedges in megathrust environments could lead to erroneous predictions of fault strength.

HIGH-RESOLUTION CHEMOSTRATIGRAPHIC CORRELATION OF THE LOWER SILURIAN (LLANDOVERY) OSMUNDBERG K-BENTONITE IN BALTOSCANDIA AND NORTHERN EUROPE

Funda O. Toprak*, and Warren D. Huff

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The Lower Paleozoic stratigraphic record in Eastern North America and northwestern Europe contains numerous altered volcanic ash beds (Huff et al., 1998). These ash beds exhibit a variety of mineralogical and chemical characteristics that can serve as useful fingerprints for recognizing them on regional scale.

The Lower Silurian Osmundsberg K-bentonite is a widespread ash bed that occurs throughout Baltoscandia and parts of northern Europe. Ordovician and Devonian K-bentonites in North America and Europe have been subjected to relatively numerous investigations in recent years, whereas only a few ash beds of Silurian age have been subjected to investigation. Because of its potential significance for stratigraphic and paleovolcanological application, the sections containing the Osmundsberg K bentonite beds were investigated to determine if chemical composition of these beds can be used as a basis for high-resolution chemostratigraphic correlation on a regional scale and geochemical data were applied to the interpretation of the tectonomagmatic setting of the source volcanoes produced Osmundsberg.

Fifteen Osmundsberg K-bentonite samples and twenty-six samples of accompanying beds from twelve different localities were analyzed for major and trace elements and the data statistically treated using discriminant function analysis to determine if the trace element data provides a unique chemical fingerprint for the Osmundsberg K-bentonite beds. Comparison with the correlation model drawn by Bergström et al. (1998) based on biostratigraphic evidence show that results from two independent techniques are generally in agreement.

Identification and classification of K-bentonites using statistical analysis is a useful stratigraphic tool, which can be most helpful where conventional methods are inadequate such as the absence of a good biostratigraphic control as in this case. Results demonstrate the unique and identifiable chemical fingerprint for the Osmundsberg K-bentonite does exist and can provide an additional stratigraphic tool for local and regional correlation of these K-bentonites.

References

Bergstrom, S.M., Huff, W.D. & Kolata, D.R. (1998) Early Silurian (Llandoverian) K-bentonites discovered in the southern Appalachian thrust belts, eastern USA: Stratigraphy, geochemistry, and tectonomagmatic and paleogeographic implications. *GFF,* **120**, 149-158.

Huff, W.D., Bergstrom, S.M., Kolata, D.R. & Sun, H. (1998) The Lower Silurian Osmundsberg K-bentonite. Part II: mineralogy, geochemistry, chemostratigraphy and tectonomagmatic significance. *Geological Magazine,* **135**, 15-26.

WEDNESDAY JUNE 23, 2004

VOLCANICALLY DERIVED CLAYS

4:20PM

SULFUR ISOTOPE AND POTASSIUM-ARGON ANALYSIS OF MINERALS FROM THE TURPLU HALLOYSITE MINE, BALISIKER REGION, NORTHWEST TURKEY

Paul A. Schroeder[*1], Michael J. Smilley[1], Ö. Isik Ece[2], and Marion Wampler[3]

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Halloysite deposits situated between metamorphic dolostones and volcanic rock contacts within the Sakarya Tectonic zone of NW Turkey are potentially important economic deposits. Sulfur isotope and potassium-argon studies have been conducted to aid in the development of geochemical and structural models, which are needed to explain the mineralization pathways and spatial distribution of coexisting halloysite and alunite clays.

Potassium analysis of nearly pure alunite by inductively coupled plasma yielded a value of 6.47 weight percent. Argon analysis performed by isotope dilution procedures and noble gas mass spectrometry yielded a $^{40}Ar_{rad}$ value of 0.23 nl/g (%$^{40}Ar_{air}$ = 85.3). A K-Ar age of 0.9 ±0.1 Ma is calculated for the alunite. Preliminary K-Ar analysis of the neighboring andesite in the region yielded dates ranging from 18.4 – 21.4 ±0.6 Ma for the whole rocks and 20.9 – 23.4 for biotite separates. The younger apparent whole rock andesite ages are attributed to excess atmospheric argon, with the biotite ages interpreted to more accurately reflect the age of volcanism.

Stable sulfur isotope studies were conducted using the minerals pyrite, alunite, gypsum, and jarosite (all identified by X-ray powder diffraction). $\delta^{34}S$ values are reported relative to the C.D.T. standard. Pyrite, collected from the adjacent altered andesite, had $\delta^{34}S$ values that ranged from 0.5 to 1.5 $^{o}/_{oo}$. One sample each of gypsum and jarosite were analyzed. Both have a similar value of 3.0 $^{o}/_{oo}$. Alunite $\delta^{34}S$ values ranged from 4.2 to 7.8 $^{o}/_{oo}$.

A preliminary sequence and timing of mineralization is hypothesized. Triassic collision of Gondwana and Laurentia in the paleo-region of NW Turkey took place comtemporaneously with depostion of marine limestones. Subsequent subduction and volcanism occurred during the period of 20 to 24 Ma. Regional extension and hydrothermal alteration is partially constrained to have occurred around 1.0 Ma, although it is likely that these processes started several millions of years early. Extension and hydrothermal activity in the surrounding region persist to the present. Closed system differences in $\delta^{34}S$ for coexisting sulfides and sulfates evolved from magmatic fluids under a reducing pathway (i.e., $H_2S/SO_4 = 5$) in the termperature range of 200 to 300°C predict a pyrite-alunite $\delta^{34}S$ difference in the range of 25 to 30 $^{o}/_{oo}$.The maximum difference between $\delta^{34}S$ pyrite and alunite values observed at Turplu is 7.3 $^{o}/_{oo}$. This difference is consistant with a hypothesis that hydrothermal fluids may have mixed with a marine sulfate source in the temperature range of 200 to 300°C.

BIOTITE AS A DISCRIMINATOR IN THE LATE ORDOVICIAN DEICKE, MILLBRIG AND KINNEKULLE K-BENTONITES

Warren D. Huff[*1], Elif Muftuoglu[2], Stig M. Bergström[3], and Dennis R. Kolata[4]

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Late Ordovician K-bentonites in eastern North America and northwestern Europe are characteristically clay-rich, but also contain primary minerals in the form of isolated and euhedral phenocrysts. Major and trace element analysis of whole-rock Ordovician K-bentonites indicates that the parental magmas consisted of a calc-alkaline suite ranging through andesite, rhyodacite, trachyandesite and rhyolite. The chemical compositions indicate a tectonomagmatic setting characterized by destructive plate margin volcanics. The Deicke and Millbrig K-bentonites are two of the most widespread and persistent of the many beds of altered volcanic ash that occur in Middle to Upper Mohawkian/Champlainian (= Lower to Middle Caradoc) strata of eastern North America. The Kinnekulle K-bentonite is the thickest and most widespread among the many K-bentonites in the Ordovician of Baltoscandia and it is generally present in sections having an apparently uninterrupted Johvian-Keilan succession. The possibility of a common source for these ash beds was suggested by Huff et al. (1992, Geology, **20**, 875). Additional information supporting this interpretation was recently presented by Saltzman et al. (2003, 9th Int'l Symposium on the Ordovician System, 137).

However, Haynes et al. (1995, Geology, **23**, 847) suggested that the proposed intercontinental correlation of the Millbrig and Kinnekulle beds is suspect. They suggested that the utility of the discriminant function analysis of whole rock compositions, which are obtained by neutron activation analysis for the correlation of K-bentonite beds, is not valid for large-scale regional or global correlations. They maintained that uncertainty results from the variable mobility of several major and certain trace elements during diagenesis might result in regional shifts in bulk composition. Haynes et al. (1995) studied the compositions of volcanically generated biotite phenocrysts that had survived diagenesis and concluded that they are more reliable as specific bed indicators than bulk rock composition. They reported a compositional difference between Kinnekulle and Millbrig biotites with respect to their FeO, MgO, Al_2O_3, MnO, and TiO_2 content. They further suggested that these variations represent separate eruptive events. However, Haynes et al. (1995) used data from only one Millbrig site in North America and one Kinnekulle site in Baltoscandia, so they failed to evaluate lateral variation as well as within bed variation in biotite compositions. Here we present a comprehensive study of K-bentonite biotite composition covering a more extensive geographic and stratigraphic range for these Ordovician beds. A total of 666 Kinnekulle biotite analyses, 97 Millbrig biotite analyses and 39 Deicke biotite analyses representing 32 separate localities provide the most comprehensive view to date of the nature and extent of internal compositional variability of these widespread Laurentian and Baltoscandian ash beds. The data show clearly that the Kinnekulle and Millbrig are multiple event ash beds, some parts of which are indistinguishable from one another. Published age dates are inconclusive as to the true ages of each bed and are thus permissive of a common age and a common origin.