surrounding pelitic schist. A regional fault, the Granville thrust cuts through the greenstone near its eastern edge and is marked by a 5 m mylonite zone. The greenstone contains epidote-amphibole-chlorite- albite-quartz; the mylonite includes garnet-muscovite-chlorite-plagioclase- quartz schist.

Two sets of chemical profiles were constructed across the greenstone body. The first set shows changes in greenstone samples from 450 to ~12 m west of the shear zone. The second set illustrates detailed changes a few meters on either side of the shear zone. In the detailed profile, many major elements (Na_2O, Fe_2O_3, MgO, CaO, TiO_2 and Al_2O_3) and some trace elements (Cr, V, Co, and Ni) show depletion within the shear zone. SiO_2 and K_2O increase in the mylonite. This is a reflection of the different mineralogy of greenstone and pelitic schist; several samples have intermediate compositions between greenstones and schists, suggesting physical mixing.

Chemical variations along the profile from 450 to within 12 m of the shear zone reveal two distinct groups: high TiO_2 (group 1) and low TiO_2 (group 2). There are concomitant variations in major elements and key trace elements such as Zr and Y. The chemical differences between the groups are believed to be of igneous origin. The two groups are clearly defined on a Ti-Y-Zr discriminant diagram, on which group 1 greenstones consistently plot in the within-plate-basalt region whereas group 2 greenstones lie in the MORB/island-arc field. These chemical variations within a single greenstone are similar to variations *among* greenstone bodies throughout the Pinney Hollow Formation. We suggest that the greenstones formed in a well-developed rift environment where both depleted (N-type) and enriched (P-Type) mantle sources partially melted to form a variety of basalt types within a small geographic area.

№ 2879

GEOLOGY THROUGH EXPERIENTIAL LEARNING

KANAT, Leslie H., and OTTUM, Margaret G., Department of Environmental and Health Sciences, Johnson State College, Johnson, VT 05656

The quality of science education in the middle grades could be greatly improved. Currently many students are bored, intimidated, or for a multitude of reasons, turned off to science and driven away from this important field of study. A modification in the curriculum and its delivery methods is needed to help students develop problem solving abilities, basic science skills, and advance the ways in which they learn and understand material. Such changes require improvement in both the science content and the methods of teaching (pedagogy). Especially important is active student engagement and effective teaching. This in turn will provide better qualified students at both the high school and college levels — students who enjoy the challenges advanced by the sciences. Geology is an ideal science for the middle school level to impart substantial disciplinary content, active presentations, laboratory work, field work, and a dynamic pedagogical style.

Inexpensive, locally derived materials for geological education at the middle grade level, coupled with innovative teaching methods, have demonstrated success. Project GEO: Earth Science in the Middle Grades, for example, used hands-on, active presentations and simple materials for student activities; examples include: •chemical and physical weathering using chalk and vinegar, •hydrological sorting using shake jars, •topography and watersheds using "human hills", •porosity and permeability measurements using coffee cans, •water wells using beakers, screen, and sand, •glacial processes and features using ice blocks, •pace and compass via treasure hunts, •superposition using sandwiches, •deformation modeled by crepe paper, •deep time modeled by window screen, •strike and dip using protractors, and •rock cycle using crayons. Project GEO also localized geology for students by providing Vermont rock and mineral collections, air photos, geologic and topographic maps of their school, and photographic slides of local geology. These methods provide students with the necessary tools to encourage them to become geological detectives in their backyard.

№ 19440

BIOGEOGRAPHIC PATTERNS OF MIDDLE CARBONIFEROUS NORTH AMERICAN ARTICULATE BRACHIOPODS

KAYSER, Richard A., BOUDREAU, Eileen M., and SABLOCK, Peter E., Dept. of Geological Sciences, Salem State College, Salem, MA 01970.

A multivariate statistical analysis was performed on 93 articulate brachiopod genera from 16 Upper Visean North American localities. Statistical analysis included cluster (unweighed pair group), principal coordinate and multidimensional scaling on presence-absence data (simple Jaccard coefficient).

The results, superimposed on a paleogeographic reconstruction, imply that latitudinal thermal barriers were not a significant factor in Upper Visean articulate brachiopod distribution patterns. Furthermore, the distributions suggest that high latitude glaciation/cooling may not have started during the Upper Visean, but during the Serpukhovian. In addition, the results show increasing endemism in the western sections of North America.

In Idaho-Utah-Nevada these endemic centers appear to correspond to latest stage deformation of the Antler Basin and creation of the Antler foredeep. Further north, endemism and strong linkages between ID-UT-NV and MT-West. Can. indicate that by the Upper Visean, Antler deformation of the entire margin was well developed. The southwestern margin (AZ) maintains a strong linkage with northern and southern Appalachian localities and does not appear to have been effected by the Antler deformation.

№ 26747

A GROUNDWATER MODEL FOR THE SPRUCE HOLE AQUIFER, DURHAM, NH, BASED ON A DETAILED SEISMIC REFRACTION SURVEY

Kerwin, Ruth A., Department of Earth Sciences, University of New Hampshire, Durham, NH 03824

The town of Durham and the University of New Hampshire are interested in using the Spruce Hole aquifer as a municipal pumping well site. The goals of this project were to determine the approximate thickness and areal extent of the aquifer, to determine the hydrologic characteristics and capabilities of the aquifer (groundwater flow directions and transmissivities), and to simulate the effect that pumping of the aquifer may have on the delicate ecosystem of Spruce Hole bog.

The Spruce Hole aquifer is a drift deposit composed of glacial till and stratified sand and gravel and is underlain by metasedimentary bedrock. A "kettlehole" bog with a unique ecosystem with rare plants and insects is located near the center of the deposit. The study area is located in the Oyster River drainage basin and is hydrologically bounded on all sides by either surface water or a drainage basin divide.

I conducted a 65 site seismic refraction survey of the Spruce Hole aquifer to estimate water table elevation, bedrock depth, and saturated thickness, as well as till elevations (seismic velocities between 1.9 km/s and 2.6 km/s) at many of the locations.

One-dimensional (cross section) and two-dimensional (map view) transmissivity based finite-difference groundwater models were developed to simulate the groundwater flow of the system and to determine transmissivity values for the stratified drift. An average transmissivity for the aquifer at each grid point in the model was determined through data from wells, the seismic refraction survey, and by matching estimated water table values with those calculated by the model. This model has produced simulations that are plausible representations of the groundwater system of the aquifer. A better understanding of "kettlehole" bog/groundwater systems can be gotten from this work.

№ 29465

TACONIC ALLOCHTHON AND BORDERING DEFORMED UNITS OF NEW YORK AND VERMONT: STRUCTURE AND EMPLACEMENT HISTORY

KIDD, W.S.F., HERRMANN, R., and PLESCH, A., Dept. of Geological Sciences, SUNY at Albany, Albany, NY 12222.

A laterally continuous system of thrust imbrication of the upper part of the carbonate shelf sequence and/or the overlying flysch/shale is mapped beneath the western boundary fault [Frontal Thrust] of the Taconic Allochthon. The more western of these faults must merge with the Champlain Thrust to the north; this thrust system climbs section to the south so that carbonates are not seen on the thrusts in the south near Albany. The more easterly faults of this system, including the Taconic Frontal Thrust, project into the west and center of the Middlebury "synclinorium"; these faults are interpreted to join the Champlain Thrust at depth. Thrusts of this system in the south are marked by thick zones of melange, which become much narrower in the north where carbonate rocks are included in the thrust slices. The Taconic Frontal Thrust is an out-of -sequence structure that cuts the tight regional folds within the Taconic Allochthon, and the Taconic Basal Thrust, on which the Allochthon was initially emplaced over shelf rocks.

Just east of the Taconic Allochthon, in the Vermont Valley, numerous thrusts imbricate the shelf carbonates and black phyllites. A major early thrust [Dorset Mtn. Thrust] separates the classic marble belts from less deformed carbonates, and a major out-of-sequence thrust [Green Mtn. Thrust] separates the carbonates from the Green Mountain Grenville basement and overlying Cambrian siliciclastics. The structure of the Vermont Valley carbonates is inferred to be a large antiformally folded duplex truncated on its eastern side by the Green Mtn. Thrust; this fold and thrust are also inferred to be part of the Champlain Thrust system. The bordering zones of the Taconic Allochthon contain much more deformation, especially thrust faults, than previously mapped; simple undisrupted stratigraphic sequences shown on previous maps are incorrect.

№ 26783

PARTICLE CLASSIFICATION, CHEMISTRY AND MINERALOGY OF BOTTOM ASH FROM A HAZARDOUS WASTE INCINERATOR IN SAUGET, IL.

KILLEEN, Kelly J., Department of Geology, Bates College, Lewiston, ME 04240

A study was conducted of a suite of hazardous waste bottom ash samples produced at a rotary kiln incinerator in Sauget, Illinois. The incinerator burns hazardous waste in many forms, including paint products, solvents and contaminated soils. Thin sections of ash from the primary incineration process were studied. Techniques used were petrography with an optical microscope and chemical analysis with a scanning electron microscope (SEM) that is equipped with an energy dispersive spectrometer (EDS). Ash particles were classified according to size, shape, mineralogy and texture. Thin sections consisted of two general particle sizes. The largest particles were between 0.4 cm and 1 cm in length; small particles were less than 0.4 cm. X-ray maps were produced of each particle type in order to determine their chemical content and to verify minerals identified by light microscopy.

Twelve different types of large particles and over twenty-five smaller particle types have been classified. Large particles were classified by percent glass content, gas bubble content, mineralogy, mineral size and shape, and relative abundance. The most

Margaret C. Brewer*: THE LOWER AND MIDDLE CAMBRIAN LEITHSVILLE FORMATION WITHIN THE WALLKILL RIVER VALLEY, SUSSEX COUNTY, NEW JERSEY: ITS STRATIGRAPHY AND ARCHAEOLOGICAL RELEVANCE [006031] ..... Booth 27

SYMPOSIUM: ALLOCHTHONOUS TERRANES IN THE NORTHERN AND CENTRAL APPALACHIANS: IN HONOR OF E-AN ZEN
Sheraton Conference Center, Emerald Grand Ballroom, Salon 1, 1:00 P.M.

Barry Doolan and Harold Williams, Presiding

OPENING REMARKS by Barry L. Doolan ..... 1:00 P

1 Gary G. Lash*: THE HAMBURG KLIPPE: RECORD OF THE DESTRUCTION OF THE PROTO-NORTH AMERICAN CONTINENTAL MARGIN [020234] ..... 1:10 P

2 Nicholas M. Ratcliffe*: SEARCHING FOR THE ROOT ZONE(S) OF THE TACONIC ALLOCHTHONS: LEAVING NO STONE UNTURNED [005822] ..... 1:35 P

3 W.S.F. Kidd*, R. Herrmann, A. Plesch: TACONIC ALLOCHTHON AND BORDERING DEFORMED UNITS OF NEW YORK AND VERMONT: STRUCTURE AND EMPLACEMENT HISTORY [029465] ..... 2:00 P

4 Pierre St. Julien*: MOVEMENT HISTORY ALONG THRUST FAULTS OF THE HUMBER ZONE IN THE QUEBEC APPALACHIANS [002952] ..... 2:25 P

BREAK ..... 2:50 P

5 H. Williams*: ORDOVICIAN ALLOCHTHONS IN NEWFOUNDLAND [002950] ..... 3:15 P

6 J.W.F. Waldron*, G. S. Stockmal: AN ACADIAN ALLOCHTHON IN THE HUMBER ZONE OF WESTERN NEWFOUNDLAND: IMPLICATIONS OF INDUSTRY AND LITHOPROBE SEISMIC PROFILES [004413] ..... 3:40 P

7 S. E. Palmer*, J.W.F. Waldron: TECTONICALLY TRANSPORTED BASEMENT AND PLATFORM ROCKS OF THE ACADIAN PORT AU PORT ALLOCHTHON, STEPHENVILLE AREA, NEWFOUNDLAND [004222] ..... 4:05 P

8 R. A. Jamieson*, S. Anderson, L. McDonald: SLIP ON THE SCRAPE--AN EXTENSIONAL ALLOCHTHON EAST OF THE BAIE VERTE LINE, NEWFOUNDLAND [004221] ..... 4:30 P

OPPORTUNITY FOR FRIENDS AND COLLEAGUES TO HONOR E-AN ZEN ..... 4:55 P

SYMPOSIUM: RIVERS AND LAKES: A TRIBUTE TO BRIAN RUST (II)
Sheraton Conference Center, Emerald Grand Ballroom, Salon 3, 1:00 P.M.

E. Gierlowski-Kordesch and M. R. Gibling, Presiding

OPENING COMMENTS by E. Gierlowski-Kordesch ..... 1:00 P

1 Robin W. Renaut*, Jean-Jacques Tiercelin: DELTAIC SEDIMENTATION IN SALINE, ALKALINE LAKE BOGORIA, KENYA: RESPONSE TO ENVIRONMENTAL CHANGE [030380] ..... 1:10 P

2 John P. Coakley*: LAKE SEDIMENT STUDIES IN CANADA: STANWELL-FLETCHER LAKE REVISITED [024122] ..... 1:40 P

3 Keddy Yemane*: UPPER PERMIAN FLUVIOLACUSTRINE DEPOSITS OF SOUTHERN AFRICA AND THE LATE PERMIAN CLIMATE IN SOUTHERN GONDWANA [004398] ..... 2:10 P

4 I. A. Nyambe*, O. Dixon: GWENBE COAL FORMATION, KAROO SUPERGROUP, MID-ZAMBEZI VALLEY, SOUTHERN ZAMBIA; A FLUVIAL FLOOD PLAIN ENVIRONMENT [002922] ..... 2:40 P

BREAK ..... 3:10 P

5 Jane R. Eggleston*: LACUSTRINE SEDIMENTATION AND ORIGIN OF THE UPPER PENNSYLVANIAN REDSTONE LIMESTONE, NORTHERN APPALACHIAN BASIN [005819] ..... 3:30 P

6 Blas L. Valero Garces*, Elizabeth Gierlowski-Kordesch: LAKE LEVEL FLUCTUATIONS IN CARBONATE SEQUENCES FROM THE UPPER FREEPORT LIMESTONE, APPALACHIAN BASIN (UPPER ALLEGHENY GROUP, MIDDLE PENNSYLVANIAN) [021055] ..... 4:00 P

7 D. E. Roach*, A. D. Fowler, G. Burbidge: ANALYSES OF VARVE THICKNESS TIME-SERIES DATA; A CLIMATE LINK? [002923] ..... 4:30 P

SYMPOSIUM: BEDROCK STUDIES IN THE NORTHERN APPALACHIANS; IN HONOR OF PHILIP OSBERG (II)
Sheraton Conference Center, Emerald Grand Ballroom, Salon 2, 1:15 P.M.

David C. Roy and Henry N. Berry IV, Presiding

1 Robert Marquis*, Stephen Kumarapeli: NEW INSIGHTS INTO THE GEOLOGY OF THE KNOWLTON-RICHMOND AREA, QUEBEC [034688] ..... 1:15 P

2 Nicolas Pinet*, Alain Tremblay: SYN- TO POST-OBDUCTION STRUCTURAL EVOLUTION OF THE QUEBEC APPALACHIANS [024146] ..... 1:40 P

3 Benoît Dubé*, Kathleen Lauziere: ALONG STRIKE KINEMATICS VARIATION OF THE CAPE RAY FAULT IN SW NEWFOUNDLAND AND ITS STRUCTURAL SIGNIFICANCE [025940] ..... 2:05 P

4 Stephen S. Potts*, Ben A. Van Der Pluijm, Rob Van der Voo: ASSEMBLY OF THE CENTRAL MOBILE BELT, NEWFOUNDLAND APPALACHIANS: DETERMINATIONS FROM PALEOMAGNETIC STUDIES [029838] ..... 2:30 P

BREAK ..... 2:55 P

5 J. P. Hogan*, A. K. Sinha: TERRANE ANALYSIS THROUGH GRANITE COLORED GLASSES [024054] ..... 3:15 P

6 David C. Roy*: THE ANATOMY OF A HYDROTHERMAL (EXPLOSION?) BRECCIA, ABBOT VILLAGE, CENTRAL MAINE [032758] ..... 3:40 P

7 D. R. Lux*, D. P. West, Jr.: NEW 40Ar/39Ar MICA AGES FROM EASTERN NEW HAMPSHIRE AND SOUTHERN MAINE: IMPLICATIONS FOR THE EXHUMATION HISTORY OF THE REGION [027512] ..... 4:05 P

DISCUSSION OF PREVIOUS PAPERS AND COMMENTS ABOUT AND BY THE HONOREE ..... 4:30 P

THE USE OF GEOCHEMISTRY IN UNDERSTANDING TECTONICS OF THE APPALACHIANS (II)
Sheraton Conference Center, Diamond Ballroom, Salon 1, 1:30 P.M.

J. C. Hepburn and J. Garver, Presiding

INTRODUCTION by J. C. Hepburn ..... 1:30 P

1 R. A. Ayuso, S. M. Barr*: LEAD ISOTOPIC COMPOSITIONS OF PLUTONIC ROCKS IN CAPE BRETON ISLAND, NOVA SCOTIA: IMPLICATIONS FOR PETROGENESIS AND TERRANE CORRELATION [024126] ..... 1:40 P

2 Paul B. Tomascak*, Richard J. Walker, Eirik J. Krogstad: PETROGENESIS OF PEGMATITES AND GRANITES IN SOUTHWESTERN MAINE [006297] ..... 2:00 P

3 John I. Garver*, P. R. Royce: CHROMIUM AND NICKEL IN SHALE OF THE FORELAND DEPOSITS OF THE ORDOVICIAN TACONIC OROGENY: USING SHALE AS A PROVENANCE INDICATOR FOR ULTRAMAFIC ROCKS [030004] ..... 2:20 P

4 Barbara Bock*, S. M. McLennan, G. N. Hanson: REARRANGEMENT OF REE'S IN AUSTIN GLEN FM. (ORD.), ULSTER CO., NY [019154] ..... 2:40 P

BREAK ..... 3:00 P

5 D. K. McDaniel*, J. H. Sevigny, B. Bock, G. N. Hanson, S. M. McLennan: EVIDENCE FOR OLD CRUST IN THE PROVENANCE OF THE TRAP FALLS FORMATION, SOUTHWESTERN CONNECTICUT [029493] ..... 3:20 P

6 Eirik J. Krogstad*: Pb ISOTOPIC COMPOSITION OF PALEOZOIC SEDIMENTS DERIVED FROM THE APPALACHIAN OROGEN [006296] ..... 3:40 P

7 Sidney Hemming*, E. J. Krogstad, B. Bock, G. N. Hanson, S. M. McLennan: Pb ISOTOPIC CONSTRAINTS ON THE SOURCE OF MILKY QUARTZ FROM THE SHAWANGUNK QUARTZITE, NEW YORK AND NEW JERSEY [029483] ..... 4:00 P

FINAL REMARKS ..... 4:20 P

METAMORPHIC PETROLOGY AND ECONOMIC GEOLOGY
Sheraton Conference Center, Diamond Ballroom, Salon 2, 1:00 P.M.

Thomas Armstrong and Stephen Howe, Presiding

1 W. D. Means*, Y. Park: EXPERIMENTAL GROWTH OF "PORPHYROBLASTS" IN THIN SECTION [019174] ..... 1:00 P

28th Annual

Northeastern Section

1993 ABSTRACTS WITH PROGRAMS

The Geological Society of America

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Eastern Section of the SEPM

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