Workshop B-5

CREATING A VIRTUAL FIELDWORK EXPERIENCE AT A FOSSIL-RICH QUARRY

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INTRODUCTION

What is a Virtual Fieldwork Experience?

Fieldtrips have long been an essential part of a hands-on Earth science course, and some teachers have long lamented increasing restrictions on getting students into the field. These trips have ranged from active problem-solving expeditions to less active show-and-tell. Technology in the 1990's began making creation of "virtual" fieldtrips, and sharing them electronically, relatively straightforward for anyone with basic computer skills and some time. Although hundreds of virtual field trips are now available over the web (some for the Northeast, for example, are at the PRI website at www.priweb.org/ed/earthtrips/northeast/northeast.htm), many of these are not much different than a slide show of someone's trip (though these too have their place). The term "virtual field*work*" is intended to have a slightly different connotation: the emphasis is on doing rather than seeing (Duggan-Haas and Ross, 2007).

People who do fieldwork are usually exploring a new place, collecting data for research, or both. "Virtual fieldwork experiences" provide opportunities for your students to experience problem solving in nature when you can't actually get them there. It provides an opportunity to connect your lessons with features your students might encounter in their own lives, and to apply what they've been learning to the way the world really looks outside the classroom walls. Ideally virtual fieldwork has some of the same active experiences as those of a geologist investigating a place for the first time. This suggests opportunities to explore and discover, to ask questions, and to look for observations relevant to answering a question about a locality. While "show and tell" at a locality can be useful in some contexts, "virtual fieldwork" is less about showing features to students and more about student activity.

Consider what we might hope students can do at a real field site several years after they have left our classrooms. Try to imagine a scenario by which they employ knowledge and understanding from your classroom in a way that's useful to themselves and others. The simplest situation perhaps is that they can see an Earth science phenomenon, in their own backyard, in their neighborhood, in a park, at a lake, at a construction site and know what meaningful questions they might ask and what observations they can make to answer them. The most basic of questions is "Why does this place look the way it does?" This question incorporates both the questions "What is the history of Earth processes that happened here?" and "What is going on here now: today and over the course of the year?" One of us (RMR) gives interpretive walks at local parks and elsewhere around Central NY. Many of the places look quite different one from the next, but the series of questions asked during the walks are almost the same, and that is the point: understanding of a set of concepts, and knowing what questions to ask in each place, are transferable across broad regions.

But how does one bring the field experience to the classroom on a regular basis, to help students with such real-world applications? This is, of course, a challenge, because transporting the complexity of even a small outcrop, and the myriad observations that might be made there, from the field to the classroom seems overwhelming. But with the availability of digital cameras, software such as PowerPoint, and greater availability of computers and projectors in classrooms, it has never been easier to present large numbers of photos, together with on-line maps, data, and any specimens brought back from the field. Virtual fieldwork experiences take some effort to do well, and never can replace the real thing, but the opportunity for creating something useful that reflects real environments has never been greater.

The beauty of creating a virtual fieldtrip thoroughly for one particular locality is that this locality can be revisited by students numerous times over the course of the year. The Earth is a system, after all, and at many places one may be able to study a wide range of phenomena from sedimentary rocks to meteorology to weathering to stream flow. Visiting a site numerous times helps students to discover how different Earth phenomena interact with each other, "multi-purposes" the effort one puts into creating a virtual fieldwork experience, and helps one to concentrate on getting to know just one site very well. In principle, colleagues creating virtual fieldwork experiences can share materials, or even be guest experts in each other's classrooms.

Research has been done into what characteristics of virtual experiences (which are used in a wide variety of educational contexts) makes them most highly effective as educational tools, but relatively little of that research has been done on Earth science virtual trips, or how they tie into teaching inquiry- and systems-thinking in Earth science. There is substantial room not only to create experiences that will complement what you are already doing in your classroom, but to create innovative approaches that might benefit your colleagues in NY State and beyond.

Application of a virtual fieldwork experience to Rose Hill Quarry, a fossil-rich Devonian shale

We will work together to consider how to bring the Rose Hill Quarry back to your classroom. Before determining what kinds of pictures and objects you want to choose to represent the site, you will need to think about the lessons to which you can apply study of Rose Hill Quarry. The most obvious units would be sedimentary rocks, fossils, and geologic history, but several other units could also be approached. Let's assume that you are introducing sedimentary rocks. You may be concerned with introducing understanding what sedimentary rocks are, how they form, and how to know them when you see them. Keeping in mind your long-term goals, you will want students to know how to ask meaningful questions about them some years down the road, even after their memories of vocabulary and facts have begun to wane.

Duggan-Haas (2005) has created an excellent vignette (in the style of the National Science Education Standards [NAS 1996]) of how a virtual field trip experience might intersect with curriculum and teacher approach. His example just happens to be a small Devonian quarry, so it is quite relevant in some respects to Rose Hill Quarry. Although there are many ways to lead an open-ended inquiry or guided inquiry investigation of the site, some of the more general virtual field trip questions that would be associated with the question "Why does this place look the way it does?" include:

- What kind(s) of rock(s) are found in the area? How do you know? What environment did these rocks probably form in?
- Describe the arrangement and variety of rocks shown in the photographs.

- Tell a story of how these rocks may have formed referring back to the photographs and what you have determined about the rock sample(s).
- What has happened to this area to make it look the way it does today? (That is, what has happened to the area since the rocks formed?) Why do you think so (what is the evidence for your claim)?
- If you could go to the site, what else would you want to do to answer the above questions?

GENERAL GEOLOGIC AND PALEONTOLOGIC BACKGROUND

As part of the workshop, we will be visiting a fossiliferous outcrop in which part of the Middle Devonian Hamilton Group is well exposed. Although much of the information provided below applies to this particular succession of sedimentary rocks and its contained fossils, the general sorts background information for other localities is easily obtainable from available literature. More specific data will be collected in the field that will lead to paleoenvironmental and paleoecological conclusions in the laboratory portion of the workshop.

Paleogeographic and Geologic Setting

During the Middle Devonian, some 385 million years ago, much of what is now central and western New York was situated in the Appalachian Foreland Basin that extended roughly northeast—southwest from southern Quebec to the southwest, around present day Alabama, where it opened into the Iapetus Ocean (Fig. 1). Paleogeographic reconstructions place central New York in a low, sub-tropical latitude (30º—35º S) during Middle Devonian time (e.g., Blakey, 2005). The Appalachian basin was formed as a response to lithospheric flexure associated with tectonic loading of the Acadian Orogeny (Ettensohn, 1985, 1987) and was a site of significant accumulation of sediments shed from the eroding Acadian Mountains situated to the east. Entering through large river systems and their associated deltas, the siliciclastic sediments (mostly mud, silt and sand) were deposited on broad shelf areas later to become the shale siltstone, and sandstones that are exposed today throughout much of the region.

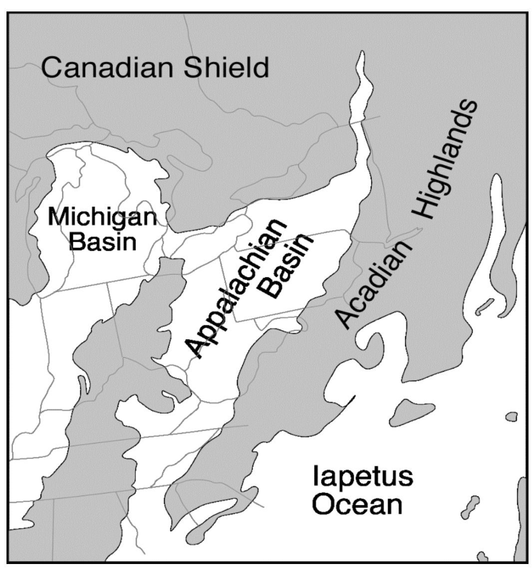

FIGURE 1—Paleogeographic map of Appalachian Basin Foreland Basin of eastern Laurentia (modified from Blakey, 2005).

The Hamilton fossil record represents one of the best-preserved, most ecological diverse well-studied marine faunas of the Paleozoic. The fossils of the Middle Devonian Hamilton Group of New York has been of considerable interest since the pioneering works of James Hall, who published between 1847 and 1894 a beautiful set of 13 monographs largely devoted to the Hamilton fauna. Within the past 50 years, Hamilton fauna has contributed greatly to our understanding within a wide range of disciplines, including stratigraphy and sedimentology, evolutionary theory, paleoecology, and the quality of the fossil record itself. Although published studies on this fauna are too numerous to list here, some of the more accessible and overarching articles include Brett (1986), Landing and Brett (1991), and, more recently, Brett et al. (2007).

The Hamilton Group shales of central NY contain fossils typical of middle Paleozoic continental seas. The Hamilton faunas in New York include many thousands of bottom-dwelling species of brachiopods, bryozoans, trilobites, corals, crinoids, and molluscs including bivalves and gastropods. Distribution of this marine fauna within the marine rocks of central and western New York is controlled by many paleoenvironmental factors, but factors that were especially important include: (1), water depth, (2), dissolved oxygen in marine water, (3), the clarity/turbidity of bottom waters, and (4), the sedimentary substrate upon (or within) which the animals lived. For example, corals and crinoids seem to favor shallow-water settings removed from significant muddy/silty input, and certain brachiopods and bivalves are more common in near-shore turbid waters and muddy and silty substrates.

Description of Rose Hill Quarry

The Rose Hill Quarry is a relatively small, privately owned, shale quarry within the hamlet of Rose Hill, Onondaga County, New York State. The quarry sits approximately mid-way between Skaneateles and Otisco Lakes, and approximately 25 km southwest of the city of Syracuse (Fig. 2).

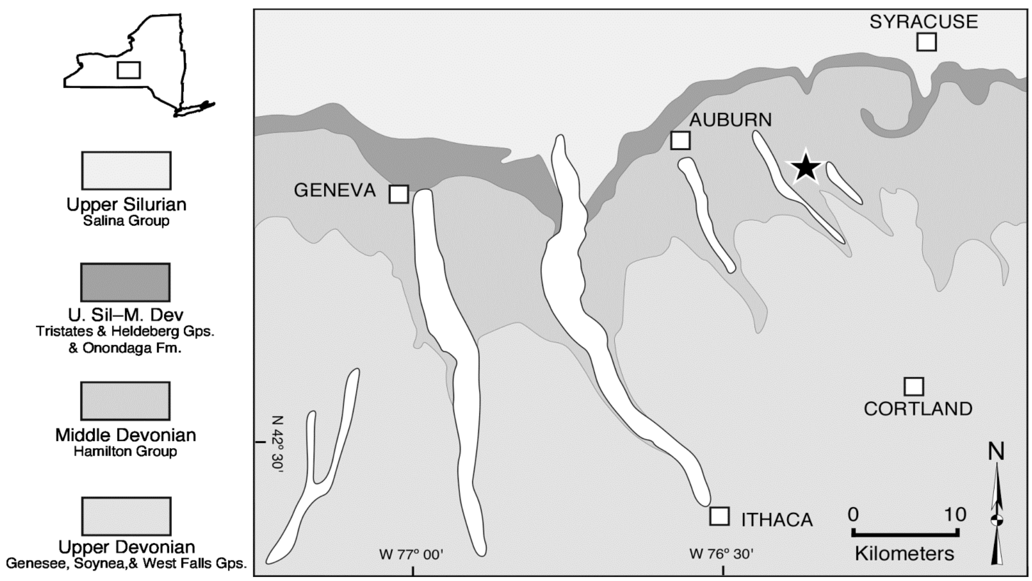

FIGURE 2—Generalized bedrock geology of the Finger Lakes Region, New York (modified from Rogers et al., 1990). Rose Hill locality indicated by star.

The quarry exposes approximately 10 meters of the upper part of the Ludlowville Formation and contains the upper part of the Otisco and lower part of the Ivy Point members (Figs. 3, 4). At Rose Hill, the lower 6.7 m of the outcrop belongs to the Otisco Member (first named by Smith, 1935) and is comprised of fissile dark gray mud shale that contains a diverse, abundant and well-preserved marine fauna. The fauna from these beds is largely contained in multiple shell beds and is dominated by spiriferid and strophomenid brachiopods with fewer numbers of bivalve mollusks, trilobites, bryozans, crinoids, and anthozoan corals. Elsewhere the Otisco Member is well known for its Staghorn coral bed in the lower part (see Trip B-2 this volume); the Rose Hill Quarry contains a few thin-beds of corals that likely correlate to the Joshua Coral Bed of the upper Otisco Member (see Oliver, 1951). Within the region, the Joshua Coral Bed can achieve thickness of up to 15 m (e.g., at Lords Hill; see Oliver, 1951), yet at the Rose Hill Quarry it is comprised of only 1-3 very thin (5 cm-thick) rugosan and tabulate coral-bearing horizons. Overlying the Otisco Member at Rose Hill is approximately 3.2 m of rusty-brown silt-shale that is attributed to the Ivy Point Member (also first named by Smith, 1935). Preservation of fossils in the Ivy Point Member is largely moldic and, with the exception of corals, which are absent in this member, contains many of the taxa found in the underlying Otisco Member.

Sedimentological and paleontological evidence you will see at Rose Hill Quarry suggests that the site was situated on what was the middle to outer edge of the marine shelf that was moderately well-oxygenated and weakly influenced by wave and storm activity.

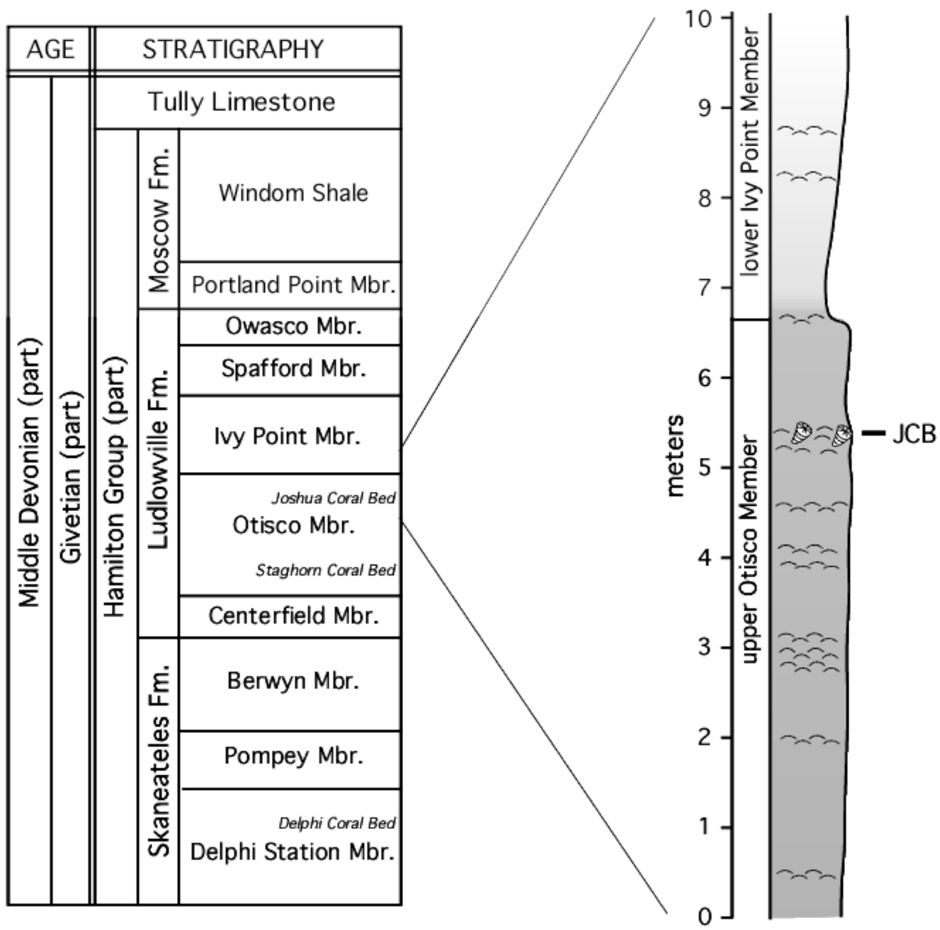

FIGURE 3—Generalized stratigraphy of part of the Hamilton Group (left) and stratigraphic section of the Rose Hill Quarry showing exposed parts of the Otisco and Ivy Point Members of the Ludlowville Formation (right). JCB = Joshua Coral bed.

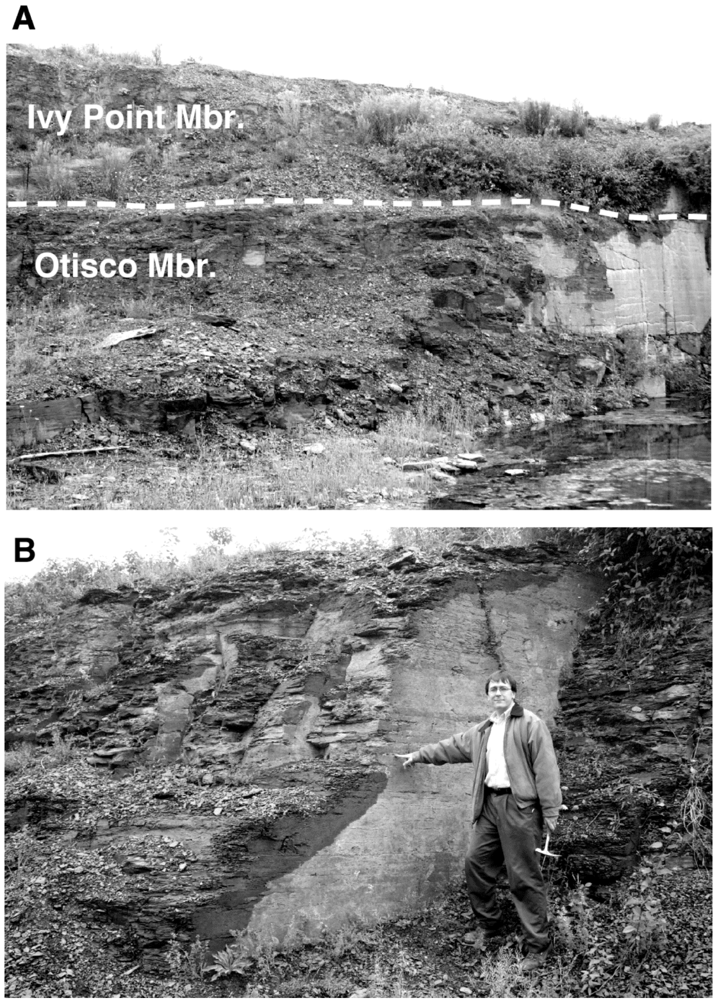

FIGURE 4—Outcrop photographs of the Rose Hill Quarry. A) approximate boundary between the Otisco Member and the Ivy Point Member. B) Showing position of the Joshua Coral bed. In the Otisco Member.

Basics in the field for creating your virtual field trip

You may have lots of field experience already, in which case you won't need reminders on what to bring and what to do at the outcrop. (If you want a fairly thorough guide, Compton [1985] is the classic.) In creating a virtual fieldtrip, however, you will need to be very systematic about the observations you make, the specimens you collect, and how all of your data is recorded, as you are doing it in proxy for your students. You should, in fact, include photographs and specimens not only of the best examples, but of a broad enough set to give a general feel for what's at the site.

Getting started

Though it may seem too intuitively obvious to note, the first step is to wander the site and get to know it yourself. (That is, resist the urge to start collecting fossils from one fossil-rich area, to the exclusion of other areas that may have fewer fossils but other kinds of geological information.) Start out by looking across the visible outcrop for signs of structures and for broad spatial changes in rock types -- both laterally and vertically. Now see if you can spot a way to move from lower in the rock section to higher and "get your nose to the rocks." Observe how rock types, fossils, and small sedimentary structures change vertically, which of course reflects how environments changed through time.

Documentation in the field

Photographs.—It will be helpful to keep careful track of the location and orientation of the pictures you take. This will help you remember how the pictures go together, and likewise help your students visualize the site. You might want to hold off on taking pictures of your site until you've explored the site and have a plan for how to communicate the site to your students visually. Use or make a map to indicate the place and direction at which your pictures are taken; in most places, and at the small scale you may be working, you will have to draw your own map, but you may be able to get topographic or aerial maps for other locations.

Your pictures should have a scale that makes it obvious the size of the geologic features in the photos. Common scales are people (especially yourself, since you will be interesting to your students), a hand pointing, or a standard rock hammer. For close-up photos traditional objects are quarters, Swiss Army knives, or rulers with a series of centimeter-sized blocks.

Notes, drawings, and Polaroid photos.—Now matter how many digital pictures you take, you are likely going to need to make some drawings, at the very least to record information about your pictures and the specimens. It will be helpful to use either a 'Rite in the Rain' notebook or to bring a large transparent plastic bag big enough to hold your notebook in case it rains. It can be helpful to use a Polaroid camera so that you can write notes directly onto photos. Polaroid photos are somewhat expensive and the quality isn't high, so these pictures do not replace others that you are taking for your virtual fieldtrip.

Measuring the section.—In research it is generally important to measure precisely where observations are made in a vertical section, thus it is necessary to measure any particular section from the bottom as a means of documentation. For teaching purposes it is possible to use basic tools such as meter sticks and long tape measures to make sure that your samples are collected at appropriate intervals and that your outcrop descriptions are accurate. Figure 3 shows a measured section for the outcrops we are visiting.

Collecting specimens and bulk samples.—You will undoubtedly want to collect specimens, especially fossils, at the Rose Hill Quarry site. Some of these will be useful simply as examples of the kinds of fossils that can be found in Central New York. You can also collect directly from the outcrop, either for individual samples or for "bulk samples," which are samples of a certain volume of rock or sediment (irrespective of the fossils that are in it). Bulk samples are what we will use to study changes in the fauna through the section. Collecting directly from the outcrop is often more work and less productive than collecting from the loose shale, if you are simply trying to create a large collection of diverse Middle Devonian marine fossils. But of course if you are trying to look for changes through time within the rock section you will need to collect from specific points along the outcrop.

Keeping locality data with your specimens is key to having a scientifically useful collection (that is a model to your students) and being able to use your specimens with your virtual fieldtrip. Even if you collect loose specimens from the piles of broken shale at the base of the cliffs, while you will *not* know precisely from which layers the fossils originated, you *will* know that they came from the Otisco or Ivy Point member of the Ludlowville Formation at Rose Hill Quarry. Since specimens so easily become separated from the label that identifies their locality, it is useful to number your specimens in some way. Putting numbers on specimens with a permanent marker right in the field, and identifying the position of the samples in the field on a diagram, is an excellent way to make sure locality documentation takes place.

Materials to bring into the field

To make a virtual fieldtrip you will need essentially the same equipment you might bring into the field anyway, except that you might bring more material for documentation. Here is a brief checklist.

- A digital camera of any kind. Film cameras will do if you are willing to pay for or make digital photos from the negatives, but with a digital camera you'll feel free to take any number of photos and you can use them on your computer immediately after being in the field.
- Digital video cameras are terrific if you have one and know well how to edit the results on your computer.

- A note book and pencils. 'Rite in the Rain' brand notebooks (www.riteintherain.com) are a good investment for long-term use, as they can get wet and still be used.
- Topographic map of the area, including a copy that you can write on.

For collecting specimens:

- A rock hammer is helpful (chisel-head is better for sedimentary rocks). While you can collect loose material that is useful at many outcrops, you need a rock hammer to collect fresh samples directly from the outcrop, for example if you are collecting from a specific point. Chisels made for rock are also useful, and butter knives are handy for splitting shale.
- Goggles or other eyewear protection

For collecting and bring specimens home you'll need:

- Zip-lock bags and small specimen boxes; tissues and paper towels are good for fragile specimens.
- Soda flats (shallow cardboard boxes) or inexpensive small plastic totes.
- Sharpie (permanent) markers to mark bags and rocks with specimen numbers.

A few other items that are useful in the field:

- Hand lens (about 10X).
- Pocket knife.
- Brunton compass if you have access to one (for measuring strikes and dip angles).
- Tape measure and/or measuring stick.

Special Projects

To provide more of a research experience for the class or for specific student projects, you may choose to go beyond an inquiry-based discussion of the site to have students collect data toward investigating a problem. Most paleontological research today starts with a specific question, for which the answer provides information about a key process of interest, such as how and when evolution and extinction occur, how rapid sea level changes during certain time intervals and what environmental impacts it has, and so on. To give a data-collection project meaning, it is important to frame it within one of these larger questions. Ideally, students might choose the question they wish to investigate, suggest a hypothesis that they will be testing, and figure out what sort of data to collect to test their hypothesis. It is possible to collect data for exploratory purposes such as documenting changes in faunas through the section and laterally along the section without a specific hypothesis in mind, but for scientific meaning one must still assume that there is a larger context in which the data might be of interest. This approach is typical primarily of those describing a rock section for the first time; such an empirical activity would have more meaning for your students if you make it clear ahead of time that you intend for your class to provide detailed descriptions of the site, toward a particularly purpose, that will be of eventual interest to scientists.

The significance of Central New York Fossils

One of the reasons New York Middle Devonian Hamilton Group shales are so important in paleontology and geology is that the geological sequences are thick, well-preserved, and fossil-rich, and therefore record in a relatively detailed way the changes in environments and faunas that occurred over a span of several million years in the Paleozoic Era. Although there are fossil marine organisms preserved all over the world in every interval of time, in many places there is not as much sedimentary rock per unit time interval (not as much sediment deposited), there are significant missing intervals of time (unconformities), or fossils were not well-preserved. Although in Central NY the shales and fossils within them look somewhat similar throughout the

Hamilton Group, there are some subtle changes that are important clues to changes in water depth, sedimentation rate, and other key variables. There are cycles of sea level change of at least 10 or 20 meters; it isn't clear what caused them, but some believe it may have been Milankovitch cycles (the same cycles that cause glacial-interglacial cycles of the Quaternary). On the whole, the taxonomic composition of the faunas stays fairly stable throughout the time interval, and the species are probably tracking (moving along with) their preferred environments. Species themselves seem to be rather stable morphologically. For most places and times represented by Hamilton Group rocks, changes through time have not been documented in a great amount of detail, primarily because there aren't enough people to do all the work (this turns out to be true for much of our study of nature). Then at the end of the interval, after deposition of the Tully Limestone, the faunas change dramatically, many species go extinct, and the marine faunas are never again quite the same.

You and your students can collect data in detail in one sample from the Rose Hill Quarry or elsewhere, looking in detail at the composition of skeletonized fauna at one point in the Devonian. If you and your colleagues take several samples and work collaboratively, you can look at what sort of changes occur through time at the Rose Hill Quarry outcrops. This is what we will begin to do together in the lab and is the subject of the next section.

Collecting samples to document faunal change

While it is fun to simply collect as many different kinds of fossils at a site as possible, unless they are simply doing reconnaissance work, paleontologists normally sample the fossils in some regular way in order to understand better what the fossils indicate about evolution and ecology. In order to do this, samples are taken from a specific layer or thickness of shale (say, 2 cm), and roughly the same volume of rock might be removed for each sample. These samples represent some limited amount of time -- perhaps hundreds or even thousands of years, but still much less than the whole stratigraghic section. Samples are typically taken at regular intervals, for example, one sample per meter, or every ten centimeters. It would be convenient to take samples every unit interval of time, such as every 10,000 years, but we can't currently date these sedimentary rocks so precisely, so we use thickness of accumulated sediment as our best approximation. We will collect samples like these from the Rose Hill Quarry section and compare the faunas at different points in time, and at roughly the same time but a several meters apart to look at spatial variability. Note that there is no published data from this site, and so whatever we learn will be new. The same could be said about similar projects applied to many other stratigraphic sections that you could study with your students.

The most straightforward way to describe changes in faunas is to count specimens of different taxonomic groups that are reasonably recognizable. Examples include brachiopods, bivalves, gastropods, trilobites, and so on. As a gross generality, different taxonomic groups tend to prefer different ecological conditions (though there can of course be *lots* of variation with taxonomic groups too), so simply by counting how many of each group are in your samples you can get some feel for how the faunas are changing. In addition to the "body" fossils, you can also have your students count "trace fossils" -- evidence of movement such as tracks and burrows that are rather common. We often don't know what kind of organism left them, yet the abundance and shapes of these trace fossils do correlate with environmental characteristics.

Paleontologists will typically do such an analysis using individual species rather than higher taxonomic groups, and your students can too if they have time to try it. We have tried this approach with 4th to 9th grade students and assessed resulting data quality (e.g., Harnik and Ross, 2003). You can start with a list of species that are likely to be found based on faunal lists from similar places. It is not strictly necessary to know species names, however, unless you wish to share the data with others, as the species names are not important for the students to learn; in fact, they can intimidating. Alternatively, you can ask the students to determine themselves what the species are and to give each species a letter or number. This may seem complicated, but it is what people tend to do on their own informally (though with some error) when they go fossil collecting. In this case you might create a two-step process, firstly coming up with a set of species that everyone agrees upon, and then counting how many of each of these species is in each sample. The students will need to make interpretations along the way, e.g., determining whether groups of specimens are from one variable species or more than one species, and making estimates of species identification when individual fossils are not well preserved.

Once you have collected your data, either higher taxonomic groups or species-level data, it is time to try to make sense of it. Firstly, do the samples differ in species present and in their relative abundance? Secondly, if they vary, is it in a way that seems to make sense ecologically? Are there any changes in the texture or color of the rocks that correlate with changes in the fossils? Is your data reliable? – that is, are there any biases, either in the way the sample was preserved or in the way that it was collected and studied, that could account for the changes you see?

Collecting samples to document changes in shape and size of species

There have been numerous studies done of changes in shape and size of individual fossil species in particular places around the world, yet such studies have been made for a very tiny proportion of the world's species. Some places are better than others for collecting such data; again, places that have more samples per time interval and better-preserved samples are more likely to preserve detail of change through time. Some species are also better for evolutionary study than others, in the sense that some are more likely to be represented by large enough numbers of specimens for us to feel confident that we have some feeling for the real range of variability within the species. It may be better to look along a bedding plane to be confident that you are investigating something like a "population" of the species, but often this is not practical, and one must aggregate specimens from across a couple of centimeters of shale that might represent organisms accumulated over hundreds of years. The kinds of changes we are likely to see in the Hamilton Group shales might be as likely to be "ecophenotypic" as evolutionary. This means that the changes in size and shape are due to ecological changes that affect the growth of animals such that species locally and temporarily become smaller or even differently shaped. An example in our own lives are crops that don't grow as large in poor soils or arid summers, or oddly-shaped trees growing in marginal environments. It is important to note that species are not necessarily in constant evident morphological change; this does not mean that evolution does not happen, but is important data that helps us understand when and where evolutionary change does occur.

To do this kind of study you will need to make a decision about which species, if any, are abundant enough to follow through time. Then, rather than just looking visually for differences among samples, measure specific characteristics (such as length and width, which show size) or ratios of characteristics (say, length divided by width), which describe shape. Note that some species that are commonly found broken, such as trilobite exoskeletons and "winged" spirifirid brachiopods, can still be measured if you choose to make your measurement on just a commonly preserved piece of the broken shell.

ACKNOWLEDGMENTS

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ROAD LOG FOR WORKSHOP B-5
CREATING A VIRTUAL FIELDWORK EXPERIENCE AT A FOSSIL-RICH QUARRY

CUMULATIVE MILEAGE	MILES FROM LAST POINT	ROUTE DESCRIPTION
0.0	0.0	Leave SUNY Cortland parking lot and turn left on to Graham Avenue
<0.1	<0.1	At light, turn left (west) on to Groton Avenue.
0.9	0.9	Turn right on to Rt. 281 North (West Avenue).
4.4	3.5	Turn left on to Rt. 41 North. At approximately 21.1 [cumulative] miles, is the well known outcrop of Tully Limestone consisting of bedded crinoidal grainstones and carbonate mud mound (see Heckel, 1973). Continue north on Rt. 41 to the Village of Borodino.
22.3	17.9	Turn right (northeast) on to Rose Hill Road (Rt. 474) towards Marcellus.
23.5	1.2	Continue straight on Rose Hill Rd. as Rt. 474 branches to the right
25.8	2.3	Turn left onto unmarked private gravel road across from yellow house.
26.0	0.2	STOP 1. **Please note, this is a private quarry and permission from the owner should be granted before entering.**

Return to vehicles and return to SUNY Cortland for the remainder of the workshop.

END OF FIELD PORTION OF WORKSHOP