

PALEONTOLOGICAL RECONNAISSANCE OF THE FREDERIKA FORMATION, WRANGELL-ST. ELIAS NATIONAL PARK AND PRESERVE, SOUTHEASTERN ALASKA

FREMD, Theodore J., DUNN, Regan E., RICKABAUGH, Skylar J., GRAHAM, David B., National Park Service, John Day Fossil Beds National Monument, 32651 Hwy. 19, Kimberly, OR 97848, ROSENKRANS, Danny, Wrangell-St. Elias National Park and Preserve, Copper Center, AK 99573

ABSTRACT

The Frederika Formation is a largely unstudied complex of up to 600 meters of depositionally variable terrestrial volcanoclastic sediments that appear to have been deposited over several million years during the early to mid-Miocene in what is now Wrangell-St. Elias National Park and Preserve in southeastern Alaska (62°N, 144°W). These strata contain an intriguing mix of depositional sequences capable of yielding new information from a climatically variable period of Earth history, particularly in regards to understanding the nature of “pulses” of environmental change (such as the mid-Miocene climatic optimum ~ 16 Ma). Paleontological resources within the Frederika Formation are abundant. In addition to a wide variety of very well-preserved paleobotanical specimens (including *Betula*, *Acer*, *Alnus*, *Glyptostrobus* and a variety of other conifers), the diversity of lithotypes in which the material was preserved is indicative of broadly variable depositional environments (including paleosol sequences, thick coal beds, lacustrine deposits, silty tuffaceous sandstones and other tephra-rich material). Within these varied lithotypes, the potential for new discoveries of vertebrate fossils and fossil palynomorphs is outstanding, as is the potential for obtaining radiometric dates from tuffaceous deposits within these strata.

Reconnaissance work in 2001 included the aerial examination and photographic imagery of 200+ miles of pedolithic volcanic claystones and siltstones. Accessible outcrop exposures both in, and lateral to, the Frederika Formation type area were recorded with a GPS and transferred to GIS maps. Fieldwork in the summer of 2003 involved on-the-ground vertebrate fossil prospecting and paleobotanical collecting efforts of known fossil sites and the identification of new potential sites. Results from these preliminary paleontological investigations provide a basis from which comprehensive research and resource protection plans are now being developed.

INTRODUCTION

In late July and early August of 2003, Ted Fremd, Skylar Rickabaugh, David Graham and Regan Dunn prospected for and collected fossil plants from the Frederika Formation in Wrangell-St. Elias National Park and Preserve in southeastern Alaska. Besides the publication of a geologic map of the area (MacKevett, 1970), relatively little is known about the Frederika Formation. Early radiometric dating of volcanic units within the Frederika suggest that the formation was deposited during the middle Miocene

(~16 Ma). In an effort to more thoroughly understand the paleontological history of the Frederika Formation, we investigated a set of exposures in the vicinity of Contact Gulch near McCarthy, Alaska. We collected pollen samples from 8 stratified coal beds, and collected leaf megafossils from three newly identified localities (Fig. 1). From one locality, Wolverine Mountain (WR3), we collected 33 paleobotanical specimens that are currently under study along with the palynological samples, at John Day Fossil Beds National Monument (JODA) in Kimberly, Oregon. Of other paleontological interest was the occurrence of a seemingly diverse assemblage of marine invertebrates and fossil wood found in abundance in the Cenomanian-aged Moonshine Creek Formation.

PREVIOUS WORK AND GEOLOGICAL SETTING

The Frederika Formation, originally described by E. M. MacKevett Jr. (1970), is a continental unit composed of conglomerates, siltstones, shales, sandstones and several beds of coal (up to 10 m thick). The Frederika disconformably overlies the Moonshine Creek Formation, a remarkably fossiliferous marine shale containing Cenomanian-aged ammonites, gastropods, wood, etc.

A few leaf localities were identified in the McCarthy C-4 Quadrangle by USGS personnel in the late '60's, including one locality in the type area of the Frederika Formation on the east side of the Frederika Glacier. Specimens from this locality were identified by Wolfe (in MacKevett, 1970) and include examples of *Glyptostobus*, *Chamaecyparis*, *Thuja*, *Abies*, *Picea*, *Pinus*, *Tsuga*, *Salix*, *Populus*, *Pterocarya*, *Betula*, *Carpinus*, *Alnus*, *Fagus*, *Ulmus*, *Acer*, *Xolisma*, *Symphoricarpos*, and *Vaccinium*. Another locality to the east of the type area yielded plant specimens also identified by Wolfe as *Metasequoia*, *Betula*, *Corylus*, *Acer*, *Glyptostrobus*, *Pinus*, *Populus*, *Alnus*, *Betula*, *Symphoricarpos*, and *Picea*.

Given the extent of the outcrops, this probably represents a minimal account of the diversity of species represented in the localities. No fauna, vertebrate or invertebrate, was reported from the Frederika by MacKevett (1970); however, the reconnaissance geology field party could have easily overlooked them. At least one fossil fish from the Frederika has been observed, collected, and reported by visitors. Careful prospecting and quarrying by experienced field staff may yield many more taxa; any vertebrates recovered from this globally "sterile" latitude would be of significance.

METHODS

Field Methods

Strata that likely contained fossil leaves were identified from aerial reconnaissance by Ted Fremd and Sylar Rickabaugh in 2001. Coordinates for promising localities were recorded using a GPS unit, and were placed on the geologic map. Once on the ground, fossil plant collections were made in the field by splitting leaf-bearing rocks with bricklayer's hammers along bedding planes. Specimens deemed "high-quality", that is complete or nearly complete specimens preserved with at least secondary venation, were wrapped in tissue paper and transported from WRST to John Day Fossil

Beds National Monument (JODA) where they are currently under study. All collected specimens were given WRST catalogue numbers and were entered into the National Park Service's collections database, Rediscovery. Included in the Rediscovery records, is all relevant information pertaining to the specimens including locality information, lithology, catalogue number, physical location of specimens within JODA's collections, and links to photographs of each specimen that can be found on the included CD.

Samples for pollen analysis were obtained from several stratified coal beds by digging down at least 20 cm to reach unweathered coal. One half of each pollen sample was sent to Doug Nichols of the USGS for pollen processing, while the other halves of the samples were maintained as voucher specimens in JODA's collections.

Morphotyping

All collections made were morphotyped according to the methods of Johnson (1989), and as specified in the Manual of Leaf Architecture (Ash et al., 1999). The morphotyping system is independent of the Linnean system of nomenclature. Historically, paleobotany has been plagued by taxonomic misclassifications. Fossil taxa were often assigned to modern genera based only on superficial similarities. By using the morphotype system, one can avoid perpetuating erroneous taxonomy, and instead concentrate on paleoenvironmental, paleoclimatological, and biostratigraphic questions. The morphotyping process involves designating unique leaf types as morphotypes based on leaf characters including leaf margin, apical and basal characters, and venation patterns. A morphotype exemplar, or the best representative specimen of each unique morphotype was assigned, and catalogued with a WRST catalogue number and an official morphotype number (e. g. WS1=Wrangell-St. Elias 1). Each morphotype exemplar from this study was photographed (Plates 1–2). The morphotypes will be studied further so that taxonomic assignments can be made in the future. Some of the more obvious morphotypes have been identified to genus (see Plates 1 and 2), and are indicated as such in the collection records.

SUMMARY OF RESULTS FROM 2003 EXPEDITION

Three new Frederika Formation leaf localities were identified on our 2003 expedition in the vicinity of Contact Gulch (Table 1). They are: 1) Wolverine Mountain (WR3), WR7, and WR8. Five marine invertebrate and fossil wood localities in the Cretaceous Moonshine Creek Formation were also identified and had collections made from them (WR1, WR2, WR4, WR5 and WR6).

A short section of strata (~34 m) from a prominent outcrop face containing stratified coal beds (beginning at 07 V 0430121E, 6822015N) located below the cliff forming volcanic unit mapped by MacKevett as the *Tif* or the “hypabyssal unit” was measured (Fig. 2 and Table 2). Seven of the numerous the coal beds in the section were sampled for palynomorphs and are currently under review by RD.

Examination of fossils collected from Frederika strata was instructive. In addition to a wide variety of very well-preserved and diagnostic specimens, the diversity of lithotypes in

which the material was preserved is indicative of broadly variable depositional environments. Matrices ranged from laminated micrites suggestive of lacustrine deposits, to small ironstone nodules suggestive of paleosol concretions, to silty tuffaceous sandstones and other tephra-rich material that contained well-preserved plant material. Relatively abundant leaf megafossils include *Glyptostrobus*, *Acer*, *Alnus*, *Salix*, and other taxodiaceous conifers; several other genera were also observed. Petrified wood appears to be relatively common, as do thick beds of lignite. Very fine detail is preserved in some of these lithologies, including impressions of reproductive plant tissues and fish scales.

The lithology of WR3 consisted of a 0.5 m thick, light tan, laminated, micritic shale sitting on top of a coal seam of undetermined thickness. Based on this, we interpret the depositional environment of the locality to be lacustrine in nature, the lateral extent of which was not explored on this expedition. The WR3 site was dominated by a species of *Alnus* (WS7, Plate 2a and 2d) or alder and a taxodiaceous conifer possibly *Glyptostrobus* (WS9, Plate 1d).

A summary of the flora from all three Frederika Formation localities follows (see Plates 1 and 2):

Locality WR3:

8 dicotyledonous angiosperm leaves

WS16-*Salix* sp. (Plate 2b)

WS17-*Juglans* sp. (Plate 2f)

WS19-*Alnus* sp. (Plate 2c)

WS7-*Alnus* sp. (Plate 2a and 2d)

WS14-*Ulmus* sp. (Plate 2i)

WS22-unidentified dicot leaf (Plate 2e)

WS13- unidentified dicot leaf (Plate 2h)

WS15- unidentified dicot leaf (Plate 2j)

2 conifers

WS9-*Glyptostrobus* sp. (Plate 1d)

WS23-*Abies* sp. (Plate 1e)

1 sphenopsid

WS20-*Equisetum* sp. (Plate 1h)

Reproductive Structures

3 winged seeds

WS4-*Acer* sp. samara (Plate 1f)

WS18-unidentified seed (Plate 1g)

WS11-unidentified seed (Plate 1i)

2 catkins-unknown affinities

WS8-cf. *Betulaceae* (Plate 1k)

WS6

Miscellaneous Structures, not figured in plates

WS5-probably a reproductive structure

WS12-branch with node

WS10-possibly a flowering axis

Locality WR7

1 dicot leaf
WS21-Plate 2g

Locality WR8

2 monocotyledonous angiosperms
WS1-.unidentified monocot (Plate 1b)
WS2-cf. *Potamogeton* (Plate 1c)
1 fern
WS3-cf. *Polypodium* sp. (Plate 1a)

Pollen Samples

Collected 8/1/03
RD8032-from coal below leaf locality WR3.

Collected 8/2/03
RD8033-RD80310 See stratigraphic column (Fig. 2) and Table 2 for vertical placement of samples.

FUTURE WORK

The paleontological resources in Wrangell-St. Elias National Park and Preserve are immense for both Neogene and Cretaceous strata. The following procedures should establish at least a baseline set of data suitable for research, publication, and resource management purposes of our primary interest, the Miocene Frederika Formation.

Accomplished thus far:

Phase One (onsite):

- Examined, photographed, and pinpointed outcrops aerially using GPS. Planned future access to sites, chose 3 areas to focus effort (Contact Gulch, West Fork Glacier area, and Frederika Formation type area).
- Identified fossil leaf localities on ground and made small collection of leaf fossils.
- Collected samples from stratified coal beds for preliminary palynological analysis.

Future work to be accomplished:

Phase Two (offsite):

- Seeking funding: likely sources include National Geographic small grants, NSF, etc. Urging GRD (Geologic Resources Division of the National Park Service) support for likely high cost/benefit ratio.
- Plan logistics, assemble team (paleontologist, Park Geologist, paleobotanist, volcanic stratigrapher, medical doctor, several experienced field workers) for next field expedition (probably summer of 2005).

Phase Three (onsite):

- Describe new master section; establish investigative framework.
- Identify, name, correlate, collect, and date tuff layers within the type area and surrounding reference sections.
- Prospect for fossil vertebrate and plant localities, and place into stratigraphic section relative to marker beds/tuffs.
- Make high-resolution, quantitative collections of fossil plant specimens (both palynofloras and leaf megafossils). Attention needs to be placed on diversity and detailed stratigraphic placement to avoid “blurring” fine-grained climatic changes (if preserved).
- Measure a master section in detail and at least the three major exposures cited above.

Phase Four (offsite):

- Compare detailed data with mid-Miocene exposures of comparable age in the Barstovian John Day Basin (within John Day Fossil Beds National Monument, OR).
- Initiate paleopedology thin sections, $\delta^{13}\text{C}$, O isotopes, XRD work, etc.

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