Challenges and Obstacles to Digitizing Small Paleontology Collections

Laura Vietti, Ph.D.

Museum & Collections Manager,
Departmental Scientific Collections,
Geology and Geophysics
University of Wyoming Fossil Vertebrate Collection
Mesozoic Vertebrates
(Dinosaurs and Marine Reptiles)

W. H. Reed  E. D. Cope  O. C. Marsh
Mesozoic and Paleogene Mammals

Alphadon halleyi,
University of Wyoming Fossil Vertebrate Collection

- 40,000 specimens
- 2.6 Billion Years
- 2,600 Localities
- 1,100 Genera, ~400 Families, ~150 Orders
Challenges

• Paleo- Related
  – Fossils are extremely variable
  – Adaptive Workflows and Multiple Methods

• Small Collections- Related
  – Limited Personnel
  – Limited Funds
Fossils are extremely Data-Rich
Fossils are extremely Data-Rich

- Life
- Behavior
- Morphology
- Pathology
- Isotopes
- Tooth Wear
Fossils are extremely Data-Rich

- Life Behavior
- Death/ Decay/ Scavenging
- Morphology
- Pathology
- Isotopes
- Tooth Wear
- Scavenging
- Weathering
- Bioerosion
- Epibionts
- Breakage
- Trampling
- Lithology
- Orientation
- Rounding
- Corrosion
- Minerals
- Permineralization
- Deformation
- Replacement
- Field Notes
- Field Maps
-Associations
- Maps
- Preps/ Tools
Fossils are extremely Data-Rich

Life Behavior

Morphology
Pathology
Isotopes
Tooth Wear

Death/ Decay/ Scavenging

Scavenging
Weathering
Bioerosion
Epibionts
Breakage
Trampling

Environment/ Rivers/ Sedimentation Rates

Lithology
Orientation
Rounding
Corrosion

Deformation
Replacement
Permineralization
Minerals
Corrosion

Field Notes
Field Maps
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  - Breakage
  - Trampling
- Environment/ Rivers/ Sedimentation Rates
  - Lithology
  - Orientation
  - Rounding
  - Corrosion
- Geochemistry
  - Minerals
  - Permineralization
  - Deformation
  - Replacement
  - Geology
  - Excavation
  - Paleoecology
  - Morphology
  - Pathology
  - Isotopes
  - Tooth Wear
  - Lithology
  - Orientation
  - Rounding
  - Corrosion
  - Minerals
  - Permineralization
  - Deformation
  - Replacement
Fossils are extremely Data-Rich

Life Behavior

Death/ Decay/ Scavenging

Environment/ Rivers/ Sedimentation Rates

Geochemistry Microbes Geology

Excavation Paleoecology

Morphology Pathology Isotopes Tooth Wear

Scavenging Weathering Bioerosion Epibionts Breakage Trampling

Lithology Orientation Rounding Corrosion

Minerals Permineralization Deformation Replacement

Field Notes Field Maps Associations Maps Preps/ Tools
Fossils are extremely Data-Rich
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Major evolutionary events, 650 million years ago to the present

<table>
<thead>
<tr>
<th>Era</th>
<th>Period</th>
<th>Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cambrian</td>
<td>Neogene</td>
<td>evolution of humans</td>
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<td>Devonian</td>
<td>Paleogene</td>
<td>mammals diversity</td>
</tr>
<tr>
<td>Silurian</td>
<td>Crayaceous</td>
<td>extinction of dinosaurs</td>
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<tr>
<td>Ordovician</td>
<td>Jurassic</td>
<td>first primates</td>
</tr>
<tr>
<td>Cambrian</td>
<td>Paleozoic</td>
<td>first flowering plants</td>
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<td>Carboniferous</td>
<td>Triassic</td>
<td>first birds</td>
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<tr>
<td>Mississippian</td>
<td>Jurassic</td>
<td>dinosaurs diversity</td>
</tr>
<tr>
<td>Carboniferous</td>
<td>Permian</td>
<td>first mammals</td>
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<td>Permian</td>
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</tr>
<tr>
<td>Carboniferous</td>
<td>Carboniferous</td>
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<td>Carboniferous</td>
<td>reptiles diversity</td>
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<td>Carboniferous</td>
<td>first reptiles</td>
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<tr>
<td>Silurian</td>
<td>Carboniferous</td>
<td>scale trees</td>
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<tr>
<td>Ordovician</td>
<td>Cambrian</td>
<td>seed ferns</td>
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<td>Cambrian</td>
<td>first amphibians</td>
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<td>Cambrian</td>
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<td>jawed fishes diversity</td>
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<td>Cambrian</td>
<td>first vascular land plants</td>
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<td>sudden diversification of multicellular animal families</td>
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<td>Cambrian</td>
<td>first fish</td>
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<tr>
<td>Cambrian</td>
<td>Cambrian</td>
<td>first chordates</td>
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<td>Cambrian</td>
<td>Cambrian</td>
<td>first skeletal elements</td>
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<tr>
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<td>Cambrian</td>
<td>first soft-bodied multicellular animals</td>
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<tr>
<td>Cambrian</td>
<td>Cambrian</td>
<td>first animal traces</td>
</tr>
</tbody>
</table>

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Fossil Preparation

Storage

Research
Fossils are not 3D or 4D but 50+D

- Morphology
- Pathology
- Micro-wear
- Meso-wear
- Elemental
- Isotopic
- Minerals
- Scavenging
- Bioerrosion
- Corrosion
- Rounding
- Weathering
- Field Notes
- Quarry Map
- Time Period
- Lithology
- Sediment
- Associations
- Field Notes
- Field Map
- Field #
- Preparations
- Lab Notes
- Lab photos
- Lab #
- Preparators
- Storage
- Georeference
- Identification
- Element Type
- Holotype?
- Publications
- Research Lab
- Loans
- Interactions
- Cast
- File Type
- Consolidants
- Land Owner
- Camera Info
- Scanner Info
- Dates
- Horizon
- Determination
- Notes
- Trampling
- Sorting
- Orientation
- Strike/Dip
- Condition?
- Breakage
Fossils are not 3D or 4D but 50+D

Poses many challenges to consider when attempting to digitize paleo collections?
Fossils are not 3D or 4D but 50+D

Poses many challenges to consider when attempting to digitize paleo collections?

Complicated Workflow

Specimen by Specimen: **Adaptive Workflow** with several techniques/methods
Fossils are not 3D or 4D but 50+D

Poses many challenges to consider when attempting to digitize paleo collections?

Complicated Workflow

Specimen by Specimen: Adaptive Workflow with several techniques/methods

What do I mean?
Fossilization Process
(Variation in Color and Composition)
Fossilization Process
(Variation in Color and Composition)

- Varies across bone, skeleton, assemblage, formation, etc...
- Recording or knowledge of what they are
- Different Backgrounds
- Scanning Artifacts
- Consider important features to capture (iridescence, sutures, diagnostic markings?)
Size Variation

- Extremely Variable
- Dinosaurs to Diatoms
- Matching technology to specimen
- Requires multiple scans/photos
- All the specimen? Part of the specimen?
Shape Variation

• Varies across bone, skeleton, assemblage, formation, etc...
• Extreme Shape variation
• Flat specimens
• How Capture all of it? Do we try?
• 3D scans..stitching
Identification

- Often Difficult
- Not Possible/Diagnostic
- Outdated Nomenclature
- Multiple Specimens
  - Slab
  - Jacket
  - Changes during Prep/research
- Not Linnaean (Morphotypes)
Specimens/Bones/Lots

- How to Best Digitize?
  - Whole Specimen
  - Individual Bones
  - Assemblage?
  - By individual

- Often Changes
  - 3 Femurs identified from one specimen??
Preparations

- Varied Preparation methods and storage methods
- requires consideration when digitizing
Special Features

• Post Death Modifications
  – Cultural: Cutmarks
  – Scavenging: Bitemarks
  – Taphonomic: Weathering
  – Epibionts

• Pathologies

• Other important characteristics
Research

- Holotypes
- Paratypes
- Lithotypes
- Morphotypes

- Analyses noted and Digitized

- Researchers have very different needs and requirements for the specimens...no standardized way

Fiorenza, 2011
Metadata

- Field Data
  - Notes
  - Maps
  - Photos

- Preparation Data
  - Notes
  - Maps
  - Photos

- Curation Data
  - Photos
  - Card Catalogs
  - Identification Notes

- Research Data
  - Analyses
  - Datasheets
• Color
• Composition
• Size
• Shape
• Identifications
• Specimen/Lot Bones
• Special Features
• Preparations
• Metadata
Complicated Workflow

- Color
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Specimen by Specimen: Adaptive Workflow with several techniques/methods
Challenges

• Paleo-Related
  – Fossils are extremely variable
  – Adaptive Workflows and Multiple Methods

• Small Collections-Related
  – Limited Funds
  – Limited Personnel
Digitization Requires Multiple Methods:

EXPENSIVE

- Micro-CT
- SEM
- Next-Engine (Laser)
- Photogrammetry

Smaller

Larger
Obstacle: Cheaply Digitizing (3D Scanning) across multiple scales
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Obstacle: Cheaply Digitizing (3D Scanning) across multiple scales
Obstacle: Specialized Personnel

• Adaptive workflows
  – Imaging Backgrounds
  – Matching imaging/scanning technique with specimen
  – Adjusting to limit spectral artifacts
  – Knowledge of important features to Digitize
  – Work with a variety of scanning methods and techniques

• Knowledge/Experience
  – Identification of Specimens
  – Software Experience
  – Use of specialized equipment/software
Obstacle: Limited Funds

- **LIMITED Specialized Personnel**
  - Can work with Adaptive workflows
  - Work with multiple techniques/digitization methods
  - Expensive...few of them
  - Volunteers...requires a lot of training!
    - Volunteer Retention

- **LIMITED Specialized Equipment**
  - More than 1 type of imaging/scanning devise
  - Expensive! Constraints on Purchasing Power
  - Technical Software...or lots of it
  - Data Storage Issues
Goal of Digitization in Small Collections?

- Remote Research?
- Search tool for visits?
- Internal Purposes only?
- Outreach?
- Digitize all or limited # specimens?

- Make it Worth the Effort

- Consider Future Use?
  - What will be important/obsolete 5, 10, 20 years into future
Goal of Digitization in Small Collections?

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Goal Effects: Level of Effort, Time, Money, Detail
Balance of Resources

Digitization Goals
• Research? Query
• Level of Detail?

Fund
• Imaging/Scanning Units
• Specialized Training
• Data Storage

Personnel
• Adaptive Workflows
• Specialized Training
Worth it!

Archaeotherium mortoni
‘Terminator Pig’
Thank you!
Thank you!
Future Vision for Collections > Surface Characterization
Fossils are the MOST Informative Geologic Specimen: So much information…..but so much information

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ND Geological Survey, Becky Barnes Artist.
Curation

Use this slide as **ALL** interior slides.
Environment and evolution through the Paleocene–Eocene thermal maximum

Philip D. Gingerich

Museum of Paleontology and Department of Geological Sciences, University of Michigan, Ann Arbor, MI 48109-1079, USA
Fossils are the MOST Informative Geologic Specimen: So much information.....but so much information

- Biology
- Behavior
- Reproduction
- Feeding
- Stable Isotopes

Micro Scavengers
Macro –scavengers
Soil Properties
Precipitation

Deposition
- Travel
- Distance
- Environment
- Sedimentation rates
- Aqueous Chemistry
University of Wyoming Fossil Vertebrate Collection
**Fossil Record**

*Myobacterium tuberculosis* Complex DNA from an Extinct Bison Dated 17,000 Years before the Present

Bruce M. Rothschild,1,2✉ Larry D. Martin,3 Galit Lev,4 Helen Barcevic,5 Gilah Kahin Bar-Gol,6 Charles Greenblatt,7 Helen Donoghue,2 Mark Spigelman,3 and David Britain6

1Arthritis Center of Northeast Ohio, Youngstown, 2Department of Internal Medicine, Northeastern Ohio University College of Medicine, Kent, Ohio, 3The Carnegie Museum, Pittsburgh, 4University of Kansas Museum of Natural History, Lawrence, Kansas, 5Department of Bacteriology, Royal Free Hospital and University College London, London, 6Plantary Sciences Division, Department of Agriculture and Rural Development, Belfast, and 7Kevin Center for the Study of Infectious and Tropical Diseases and Ancient DNA, Hebrew Medical School, Hebrew University, Jerusalem

Rothschild, 2003
Fossils are the MOST Informative Geologic Specimen: So much information.....but so much information
Fossils are the MOST Informative Geologic Specimen:

So much information.....but so much information

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<td>Late Proterozoic</td>
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<td>first skeletal elements</td>
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<td>Cambrian</td>
<td>first soft-bodied multicellular animals</td>
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<td></td>
<td>Devonian</td>
<td>first amphibians jawed fishes diversify</td>
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<td>Mississippian</td>
<td>first reptiles scale trees seed ferns</td>
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<td>Pennsylvanian</td>
<td>major extinctions reptiles diversify</td>
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<td></td>
<td>Permian</td>
<td>first mammals</td>
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<td></td>
<td>Triassic</td>
<td>first dinosaurs</td>
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<td></td>
<td>Jurassic</td>
<td>dinosaurs diversify</td>
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<td>Cretaceous</td>
<td>extinction of dinosaurs</td>
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<td></td>
<td>Paleogene</td>
<td>mammals diversify</td>
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<tr>
<td></td>
<td>Neogene</td>
<td>evolution of humans</td>
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Considerations when Digitizing Paleontological Collections

• 50+D...Types of Information
• Purpose of Digitization (Quick Identification, Research, Outreach?)
• Making Efforts Worth It
• Digitize for Future Purposes

• All in the context of Small-Collections: Challenges
Fossils are the MOST Informative Geologic Specimen: So much information.....but so much information

Not 3D..Not 4D, but 50+D!
Small Collections have all and concentrated
University of Wyoming Fossil Vertebrate Collection
Mesozoic Vertebrates
(Dinosaurs and Marine Reptiles)

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Mesozoic and Paleogene Mammals

Alphadon halleyi,
University of Wyoming Fossil Vertebrate Collection

Collection Specs.
- Started in 1887
- > 40,000 specimens
- 50 Holotypes
- Teaching Collection

Mesozoic
- 10 Collections
- 3 Thesis Collections

Cenozoic
- 46 Collections
- 15 Thesis Collections
Challenges

• Paleo-Related
  – Fossils are extremely variable
  – Adaptive Workflows and Multiple Methods

• Small Collections-Related
  – Limited Personnel
  – Limited Funds
Fossils are extremely Data-Rich

- Life Behavior
- Death/ Decay/ Scavenging
- Environment/ Rivers/ Sedimentation Rates
- Geochemistry, Microbes, Geology
- Excavation, Paleoecology
Fossils are extremely Data-Rich
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Fossils are not 2D or 3D but 50+D

- Morphology
- Pathology
- Micro-wear
- Meso-wear
- Elemental
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- Holotype?
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- Scanner Info
- Dates
- Horizon
- Determination
- Notes
- Trampling
- Sorting
- Orientation
- Strike/Dip
- Condition?
- Breakage
Fossilization Types
Size Variation

- Extremely Variable
- Dinosaurs to Diatoms
- Matching technology to specimen
- Requires multiple scans/photos
- All the specimen? Part of the specimen?
Color Variations

- Varies across bone, skeleton, assemblage, formation, etc...
- Different Backgrounds
- Scanning Artifacts
- Consider important features to capture (iridescence, sutures, diagnostic markings?)
Composition Variation
(permineralization, replacement, films, mold/cast, mummification, etc..)

• Varies across bone, skeleton, assemblage, formation, etc...
• Different Spectral Properties
• Scanning Artifacts
• Recording or knowledge of what they are
Shape Variation

- Varies across bone, skeleton, assemblage, formation, etc...
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- How Capture all of it? Do we try?
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Identification

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• Not Possible/Diagnostic
• Outdated Nomenclature
• Multiple Specimens
  – Slab
  – Jacket
  – Changes during Prep/research
• Not Linnaean (Morphotypes)
Specimens/Bones/Lots

• How to Best Digitize?
  – Whole Specimen
  – Individual Bones
  – Assemblage?
  – By individual

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  – 3 Femurs identified from one specimen??
Preparations

• Varied Preparation methods and storage methods
• requires consideration when digitizing
Special Features

• Post Death Modifications
  – Cultural: Cutmarks
  – Scavenging: Bitemarks
  – Taphonomic: Weathering
  – Epibionts

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• Other important characteristics
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- Holotypes
- Paratypes
- Lithotypes
- Morphotypes

- Analyses noted and Digitized

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• Field Data
  – Notes
  – Maps
  – Photos

• Preparation Data
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• Curation Data
  – Photos
  – Card Catalogs
  – Identification Notes

• Research Data
  – Analyses
  – Datasheets
Complicated Workflow

- Color
- Composition
- Size
- Shape
- Identifications
- Specimen/Lot Bones
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Specimen by Specimen: Adaptive Workflow with several techniques/methods
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• Small Collections- Related
  – Limited Funds
  – Limited Personnel

• Considerations
  – Digitization Goals? Doing it Right? Future Research?
Multiple Digitization Methods

Micro-CT
SEM
Next-Engine (Laser)
Photogrammetry

Smaller

Larger

Expensive!
Challenge: Digitization Methods for Teeth
Challenge: Digitization Methods for Teeth
Digitization Methods for Teeth
Digitization Methods for Teeth
Specialized Personnel

• Adaptive workflows
  – Imaging Backgrounds
  – Matching imaging/scanning technique with specimen
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• Knowledge/Experience
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  – Software Experience
  – Use of specialized equipment/software
Limited Funds

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  – Technical Software...or lots of it
  – Data Storage Issues
Compromises

Digitization Goals
- Research? Query
- Level of Detail?

Fund
- Imaging/Scanning Units
- Specialized Training
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Personnel
- Adaptive Workflows
- Specialized Training