Relative Geologic Time and the Geologic Time Scale

Historical Geology Group Activity
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Objective:

This group exercise is designed to illustrate how the modern Geologic Time Scale was first developed in the 1800's, simulating the manner in which geologic systems were originally assembled into their correct time order using fossils to correlate systems across Europe. Students work as a group to build four regional geologic columns by correlating local rock sequences (systems) based on their fossils. No one region / column has a complete sequence of Phanerozoic time; students discover that a complete sequence can only be obtained by correlating stratigraphic sections from different locations. Modeling events in the history of geology, students first correlate sequences for Great Britain and Europe and then use those completed sequences to assemble the stratigraphy of the eastern and western United States. This exercise is useful for explaining how the geologic era, and periods were first assembled and named, for illustrating the principle of biostratigraphic correlation, and for demonstrating concepts such as unconformities and the difference between relative and absolute dating.

Materials:

24 geologic system sheets, 4 region labels, period and era labels
Tape
Optional string or colored tape
A large blank wall on which to assemble the stratigraphic columns

Instructions:

1. You need at least 8' of vertical wall to have enough room for building the columns. Tape the region labels in two groups near the top of the wall in the order shown on the key diagram.

2. Begin by explaining the origin of the Cretaceous System as described from northwestern France by D'Omalius d'Halloy. Tape the northwestern France sheet to the wall under the 'Continental Europe' label, leaving room for one more sheet above.

3. Distribute the remaining system sheets among the students. Tell the students that they must first build the Great Britain and Continental Europe sections by following a few simple rules:

   a. System sheets must be placed under the appropriate regional label.
   b. System sheets are connected top to bottom only when the same fossil demonstrates a continuous record of geologic time from the top of one system to the bottom of another.
   c. Systems in different regions should be placed at approximately the same vertical level if they share the same fossils.

4. As each section is located by a student and taped to the wall, you can explain the historical circumstances of that system as noted on the back of the sheet (you can have the students read these descriptions, but they tend to stumble over the unfamiliar names). Systems that became types for Period names (e.g. the Jurassic) can be labeled as they are placed on the wall. String or tape can be placed across the diagram to denote boundaries between Periods and Eras. Although the diagram is a grossly simplified cartoon, it does accurately depict the geographic location and general strata present for each classic system for which the Periods were named.

5. After assembling the Great Britain and Continental Europe sections in a deliberate, orderly fashion, allow the students holding systems from North America to quickly place their sheets on the wall using the European sections as a guide. Point out that, having established a master sequence of fossils in European rocks, it was not difficult for geologists in the U.S. to correlate their local rock units using fossils as a guide.

6. Discuss the significance of the time gap between the Upper Grand Canyon sheet and the Lower Grand Canyon sheet. Obviously, there isn't a corresponding physical gap in the wall of the Grand Canyon; what is missing is time. Point out that it is the absence of a long sequence of fossils at the boundary between the rocks of the Upper and Lower Grand Canyon that informs us that we are missing a significant amount of time.

7. Ask the student holding the Central New Hampshire sheet (igneous and metamorphic rock formations) to place the sheet in its proper position on the wall. Without fossils there is no obvious place to put this sheet. Point out that crystalline rocks were once assumed to be the oldest rocks, but that isn't always the case. Crystalline rocks cannot be dated or correlated using fossils. These rocks can only be dated using radiometric dating, which provides an absolute age rather than a relative age.

References

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Goetzmann, W.H., 1966, *Exploration and Empire*, Alfred A. Knopf.

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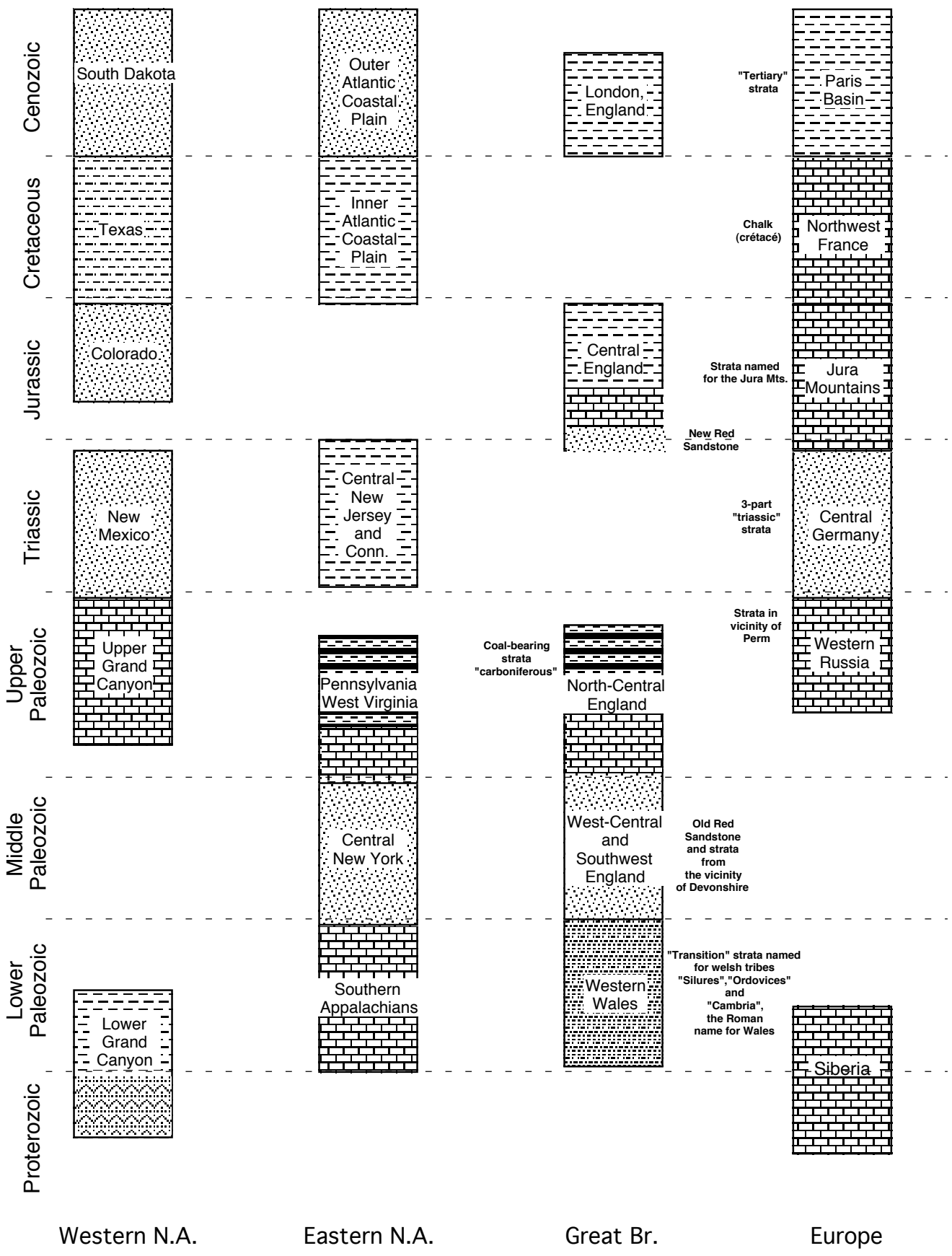
Key to fully assembled wall diagram.



Explanitory Text for Time Scale Group Project

Below are short descriptions of the strata first described in different parts of the world in the 18th and 19th centuries. Strata that formed the basis for period names in the modern geologic time scale are labeled (Type Area).

Great Britain

London, England - Tertiary
The clay layers found in the vicinity of London (a region called the 'London Basin') overlie the chalk deposits of the cliffs along the English Channel and were found by Lyell and others to contain fossils similar to those found in the strata of the Paris Basin, in France.

Central England - Jurassic
Here it was noted by William Smith in his studies from 1793 to 1798 that strata referred to as the "Oolite" and the "Lias" lay beneath the Chalk deposits of the Channel coast. Later studies would demonstrate that the fossils Smith described from these rocks were similar to those of the Jura strata on the continent.

North Central England - Carboniferous (Type Area)
The coal-bearing strata of north-central England were designated the "Carboniferous" by W. D. Conybeare and W. Phillips in their 1822 summary of the geology of Britain. Included with the coal-bearing strata in the Carboniferous was an underlying rock unit called the "Mountain Limestone".

West Central and Southwest England - Devonian (Type Area)
Originally, the "Old Red Sandstone" of west-central England was placed in the Carboniferous below the base of the Mountain Limestone. Studies in the late 1830's by Adam Sedgwick, Roderick Murchison, and John Phillips of folded layers in southwest England (Devonshire) showed that these rocks occupied the same position as the Old Red Sandstone (beneath the Carboniferous), but that they had their own, distinct types of fossils. They proposed the name "Devonian" in 1839 for these rocks that were intermediate between the Silurian below and the Carboniferous above.

Western Wales – Cambrian, Ordovician and Silurian (Type Area)
In the 1830's, two men - Adam Sedgwick and Roderick Murchison - set out to map and describe the "transitional" strata of western Wales. Murchison worked from the top (below the Old Red Sandstone) down, Sedgwick worked from the bottom up, starting in North Wales. In 1835, Sedgwick named his sequence of strata the "Cambrian" after the Roman name for Wales and Murchison named the overlying sequence of strata "Silurian", after an ancient Welsh tribe. Later, in 1879, Charles Lapworth would show that a sequence of rock layers that overlapped between the bottom of Murchison's Silurian and the top of Sedwick's Cambrian contained their own, distinctive kinds of fossils. Lapworth called these rocks "Ordovician" after the last of the British tribes to surrender to the Roman invasion.

Continental Europe

Paris Basin - Tertiary (Type Area)
Sir Charles Lyell studied the "Tertiary" strata exposed in the countryside around Paris in the early 1800's. He subdivided the Tertiary based on the percentages of extinct species of marine shelly fossils he found in different layers.

Jura Mts. France and Switzerland - Jurassic (Type Area)
Although Alexander Von Humbold was the first geologist
to give the name "Jurassic" in 1795 to a distinctive massive limestone exposed in the Jura Mountains of southern France and western Switzerland, he did not describe any fossils. By the early 1800's geologists such as William Smith were beginning to recognize that fossils similar to those in the Jura could be found in strata of central England, as well as in southern Germany.

Central Germany - Triassic (Type Area)
In the early part of the 1800's, German geologists began an intensive study of three rock formations found in central Germany - the Bunter Sandstone, the Muschelkalk Limestone, and the Keuper Clay. In 1834, Friedrich August von Alberti proposed grouping these three formations as the "Triassic" based on the distinctiveness of their fossils.

Western Russia - Permian (Type Area)
In 1841, after traveling extensively in Russia west of the Ural Mountains and observing the geology and collecting fossils, Roderick Murchison proposed the name "Permian" to describe a sequence of strata overlying the Carboniferous. These rocks contained fossils that appeared to be intermediate in form between the fossils of the Carboniferous and the fossils of the Triassic. Furthermore, Murchison noted that the Permian fossils were very similar to those in strata also found to overlie the Carboniferous in both England and Germany.

Siberia - Cambrian
In the 20th Century, sedimentary strata exposed in northeastern Siberia would be found to include a complete sequence showing the very beginning of the Cambrian as well as lower strata from the upper part of the Precambrian.

Eastern United States

Outer Atlantic Coastal Plain - Tertiary
The first fossils ever described from North America were found by early colonists in the sand layers exposed along the rivers of coastal Virginia. These fossils were later recognized to be like those of the Tertiary strata overlying the Chalk in England and France.

Inner Atlantic Coastal Plain - Cretaceous
Lardner Vanuxem, a Philadelphian of French ancestry trained at the School of Mines in Paris, demonstrated in the early 1800's that fossils found in the sedimentary layers of coastal New Jersey were similar to fossils of the Chalk in Europe, in spite of the great difference in lithology (rock type) between the two places. Later, in 1858, Joseph Leidy - a vertebrate paleontologist from Philadelphia - would travel to Haddonfield, New Jersey to excavate and describe the first nearly complete dinosaur skeleton found in North America.

Central New Jersey and Connecticut - Triassic to Jurassic
Rock layers in these two regions were found to contain common three-toed footprints (first thought to be those of large birds, but later determined to be dinosaur). These strata were recognized by Geologists in the 1800's to be similar to the New Red Sandstone of England.

Pennsylvania - West Virginia - Carboniferous (Mississippian and Pennsylvanian)
The great economic importance of coal in the 1800's led to early interest in the great coal fields of Pennsylvania and West Virginia. These were studied by Henry Darwin Rogers working as the State Geologist of Pennsylvania. The plant fossils found associated with the coal seams of eastern North America were found to be unmistakably similar to those found with the Carboniferous coals of Scotland and South Wales. Unlike their European counterparts, American geologists tended to subdivide their Carboniferous strata into an upper coal-bearing interval and a lower, mostly limestone interval. In 1891, Henry Shaler Williams proposed the names "Pennsylvanian" for the upper coaliferous strata and "Mississippian" for the lower limestone strata.

Central New York State - Devonian
The strata of New York and the abundant fossils found in them were described by James Hall - the first State Geologist of New York - in the mid-1800's. Hall recognized that the sequence of the rocks in central New York State included fossils similar to those described as Devonian in southwest England.

Southern Appalachians - Cambrian to Silurian
The complexly folded layers of the Southern Appalachian mountains were first described and mapped by two brothers - Henry Darwin Rogers and William B. Rogers in the 1830's and 1840's. Later, in 1856, William Rogers would describe trilobite fossils found in rocks of New England that were similar to fossils from the lower layers of the Appalachian mountians and from the Cambrian of England.

Western United States

South Dakota - Upper Cretaceous and Tertiary
In the 1850's, F. V. Hayden led several expeditions to study the geology of and collect fossils from Nebraska and the Dakotas. Shelly fossils were described by Meek and vertebrate fossils were shipped back east to be described by Joseph Leidy in Philadelphia. Older strata containing dinosaur fossils were found, as well as younger overlying strata containing a variety of fossil mammals, including small fossil horses.

Texas - Cretaceous
In the 1880's, R. T. Hill studied fossiliferous limestones and sandstones in Texas and recognized their equivalence to the Cretaceous System in Europe.

Colorado - Jurassic
In addition to the fossils collected on earlier Hayden expeditions, dinosaur hunters searching in Colorado in the 1880's and 1890's found an unimaginable bonanza of dinosaur skeletons - many nearly complete. These bones were shipped east and put on display in the great natural history museums of New York and Philadelphia - making headlines in newspapers such as the New York Times.

New Mexico - Triassic
The fossils and strata of New Mexico were collected and described during a number of western expeditions before and after the Civil War. Early expeditions were searching for a route for a transcontinental railroad. Later explorations were for mapping of mineral resources and scientific inquiry.

Upper Grand Canyon - Devonian to Permian
In 1857, John Strong Newberry - a pupil of James Hall back in New York, was the first geologist to gaze into the Grand Canyon.

Lower Grand Canyon - Cambrian
John Strong Newberry published a report on the Grand Canyon after visiting it in 1857. In his report he described the different layers visible in the canyon and used their fossils to correlate (match) their ages to those of European strata.

Metamorphic and Igneous Strata

Central New Hampshire
The intensly metamorphosed crystalline rocks of New England contain no fossils (in most cases, fossils are destroyed by metamorphism).

Western U.S.

Eastern U.S.

Great Britain

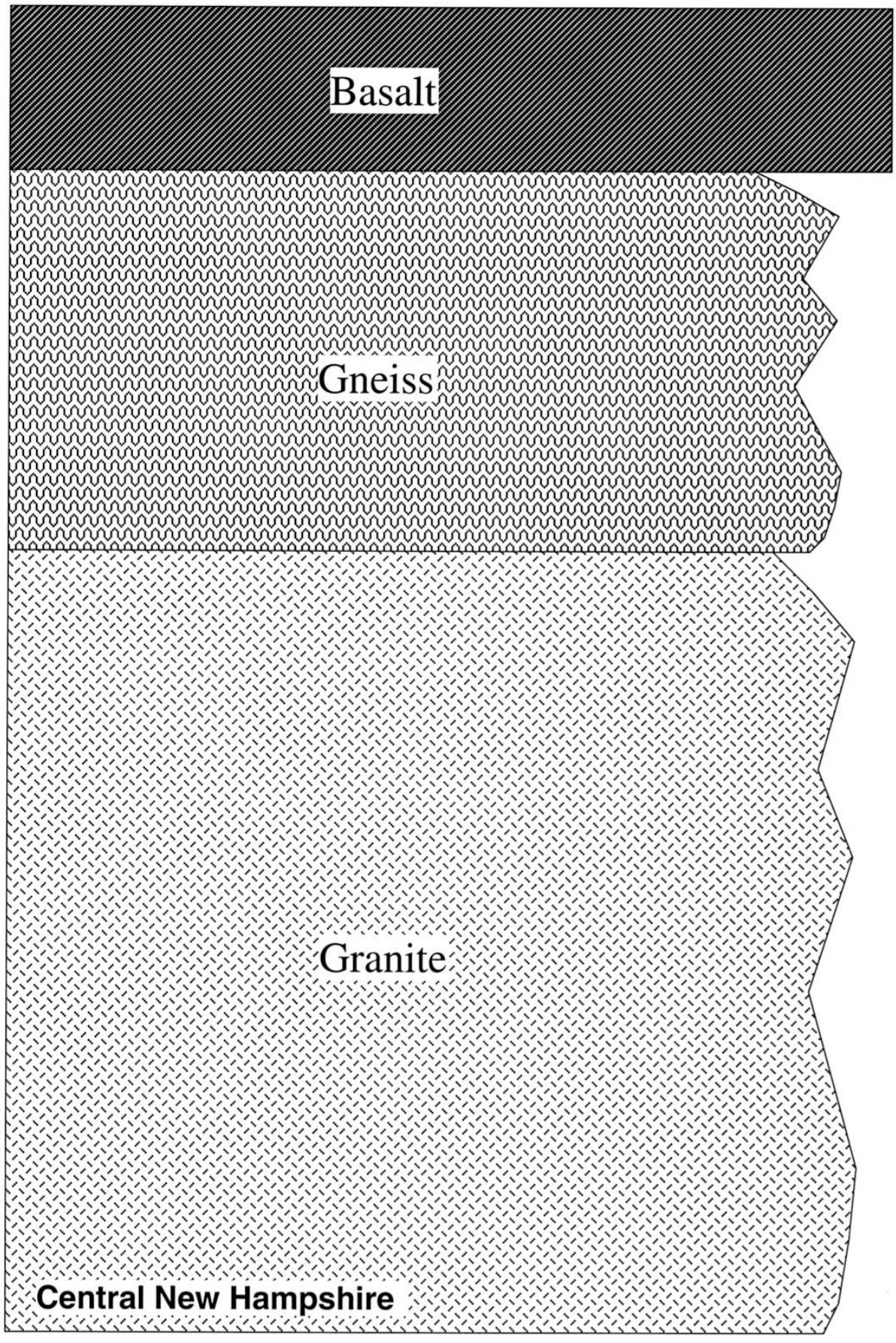
Continental Europe

Tertiary
Cretaceous
Jurassic
Triassic
Permian
Carboniferous
Devonian
Silurian
Ordovician

Cambrian

Mississippian
Pennsylvanian

Cenozoic
Mesozoic
Paleozoic


Basalt
Gneiss
Granite
Central New Hampshire

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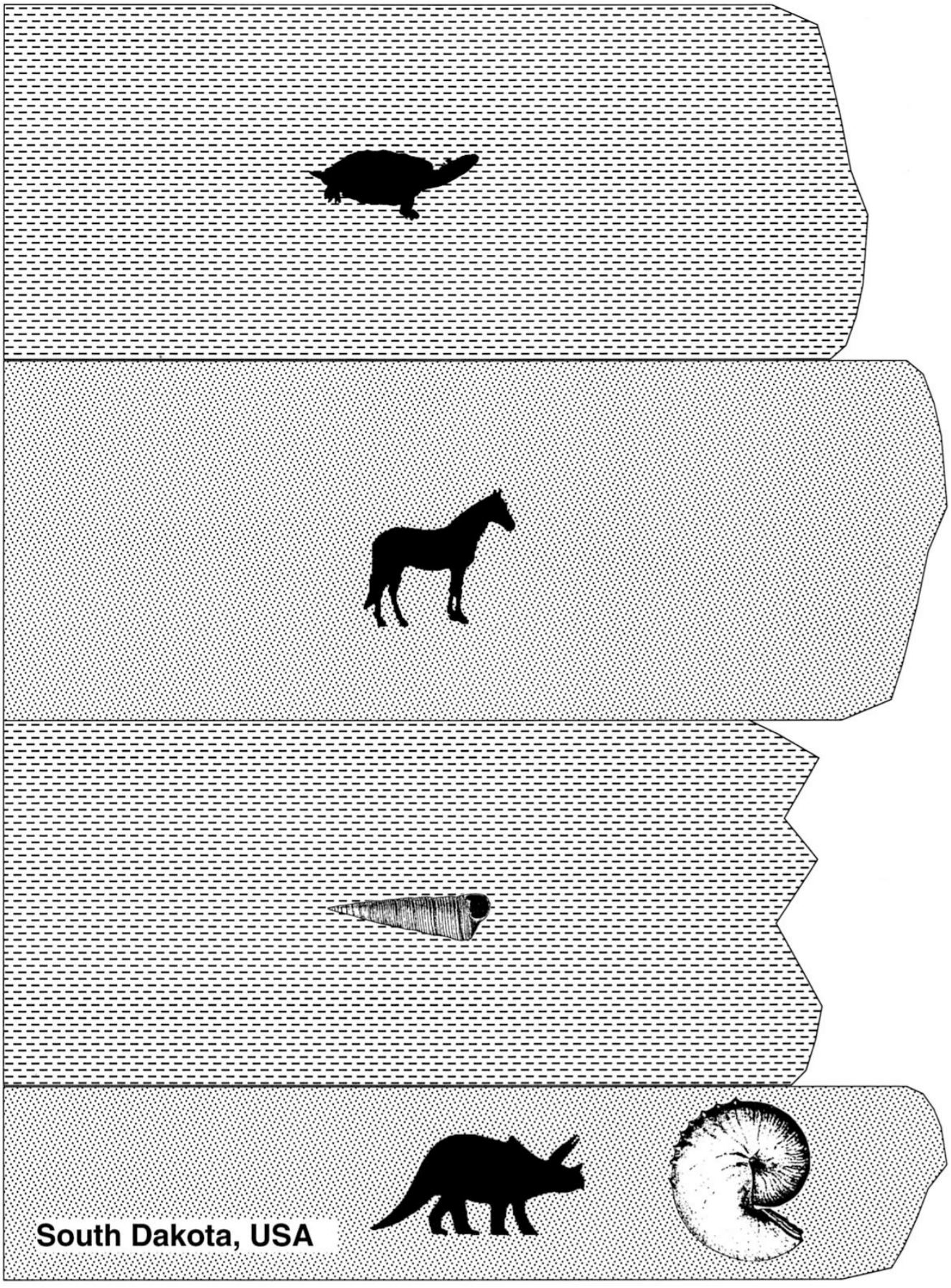
South Dakota, USA

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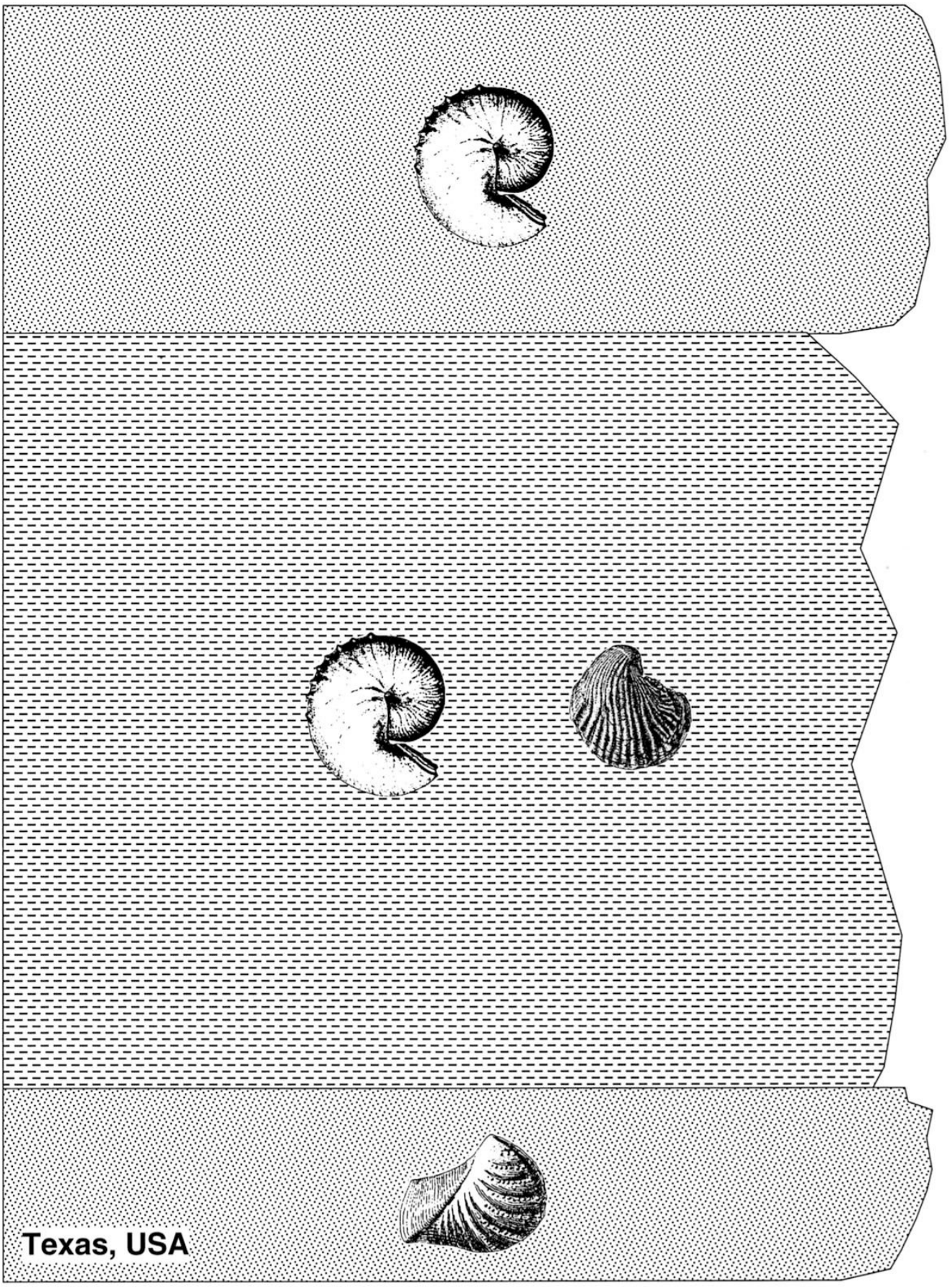
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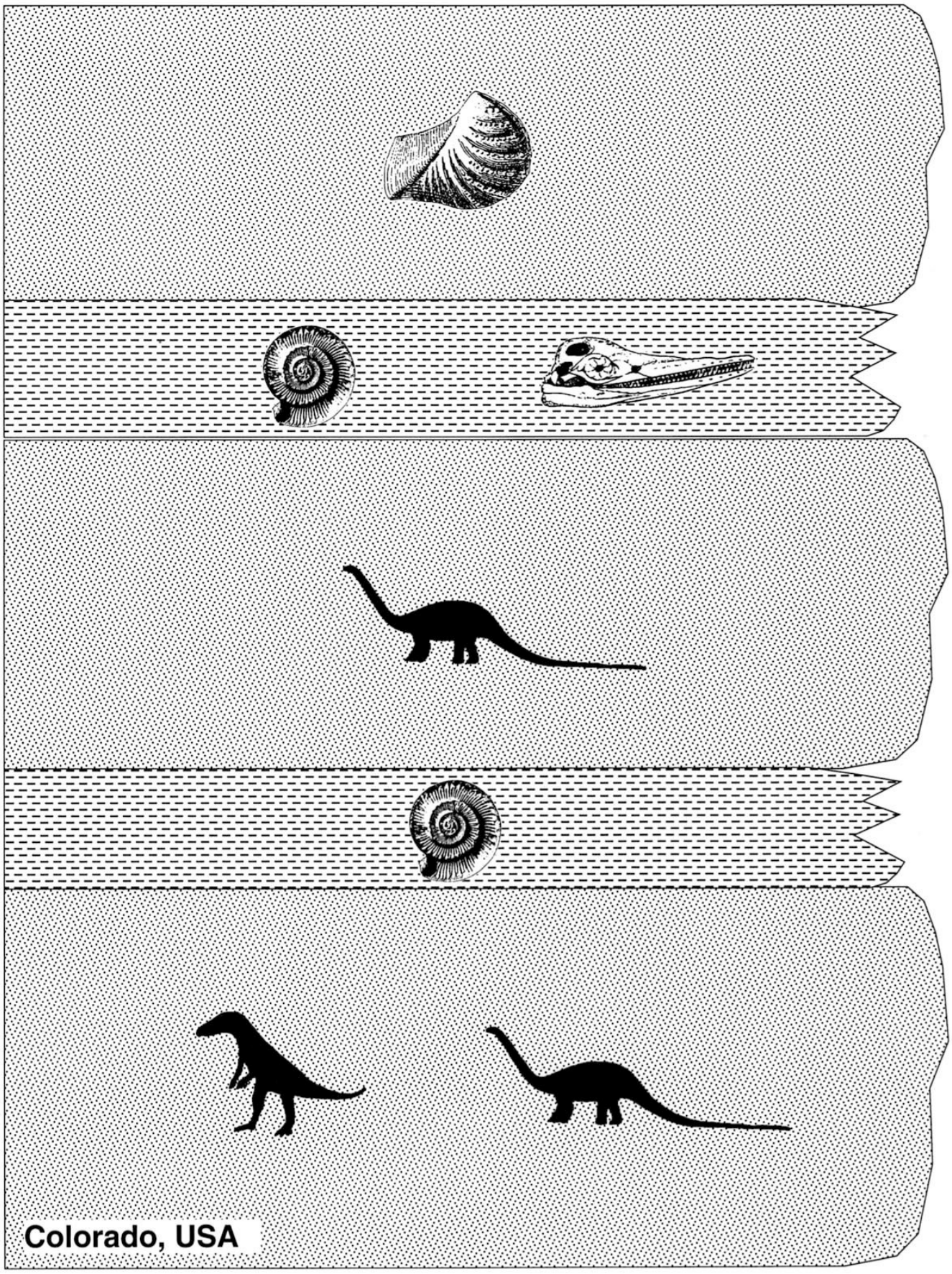
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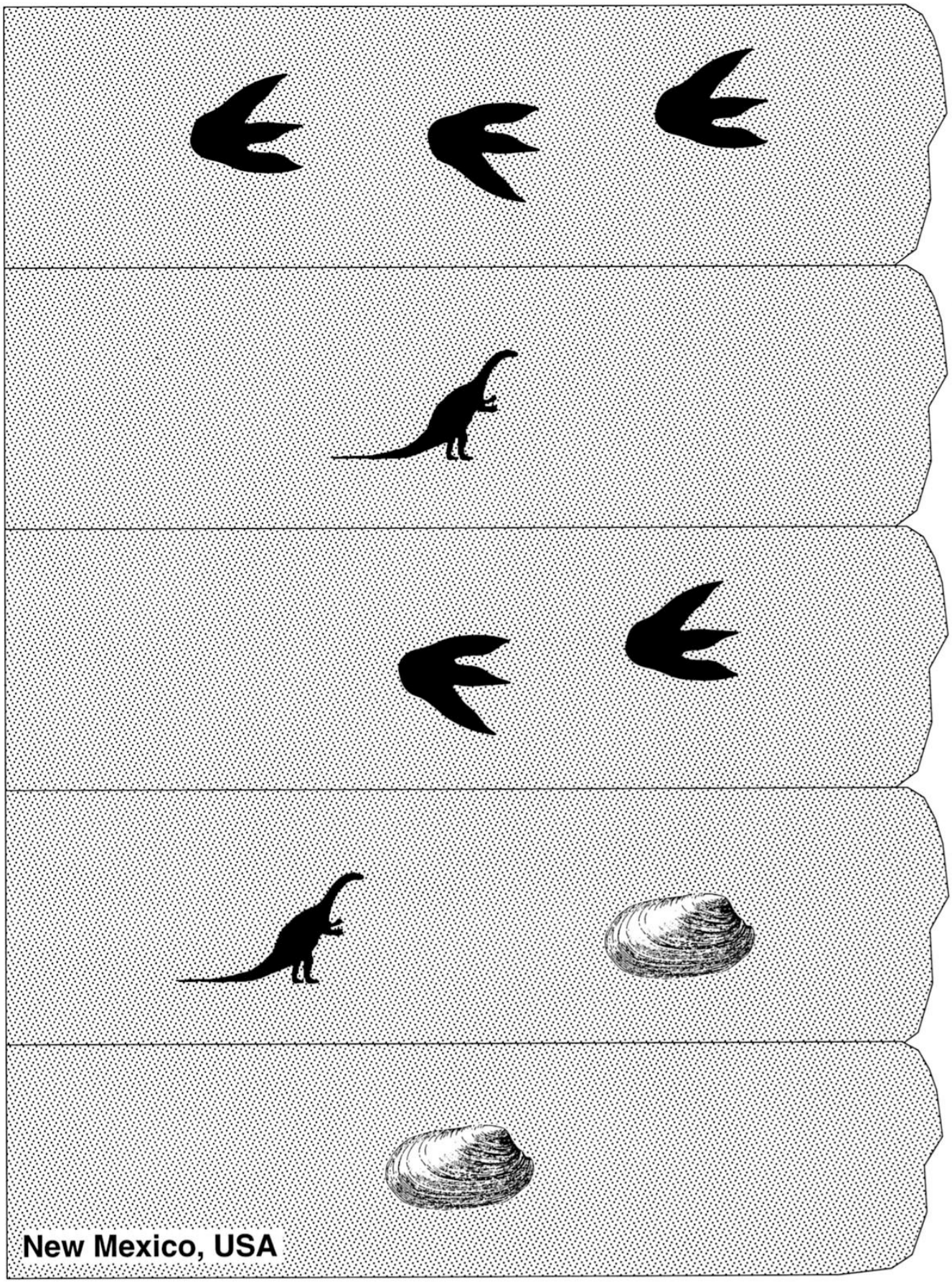
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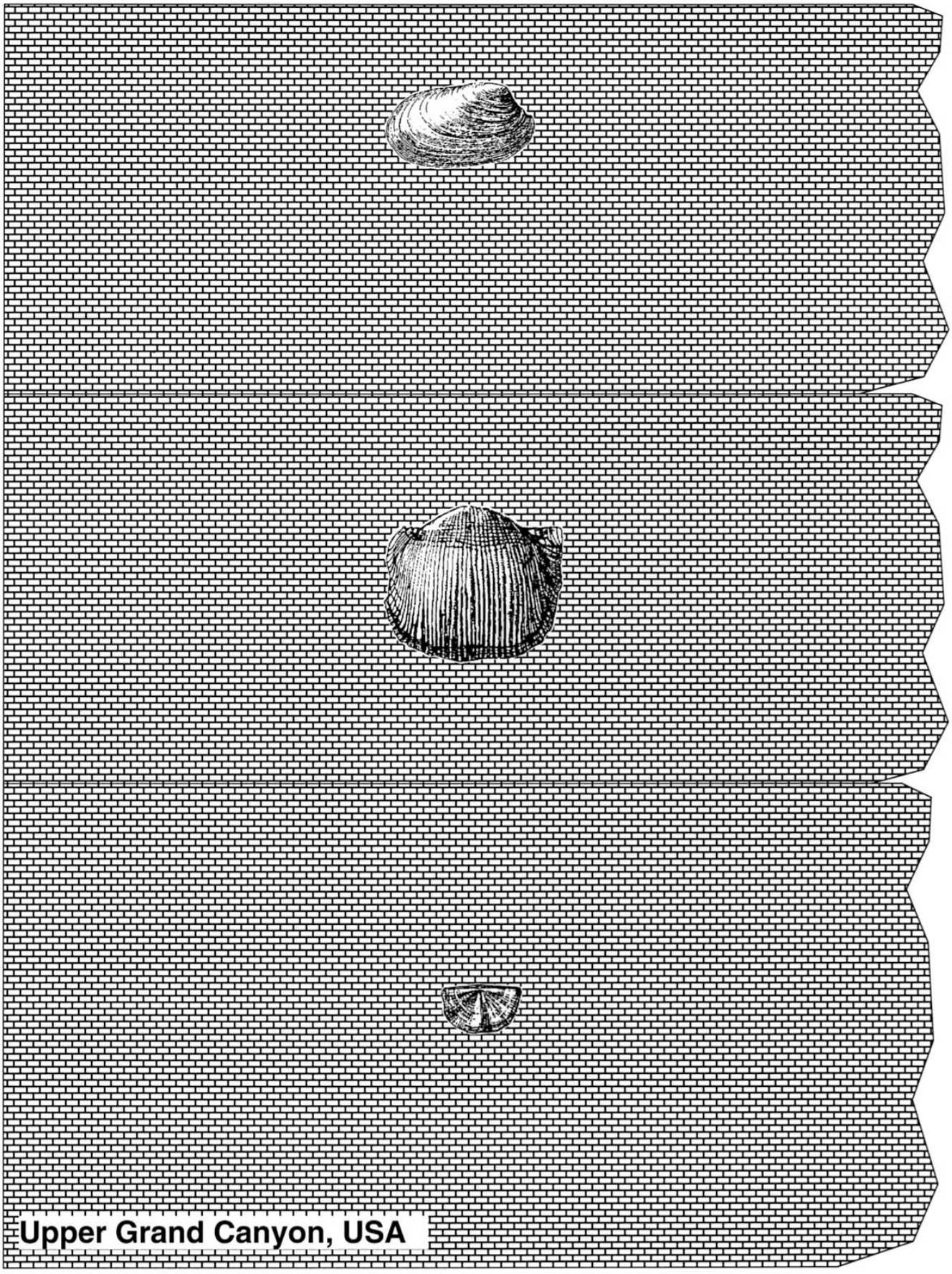
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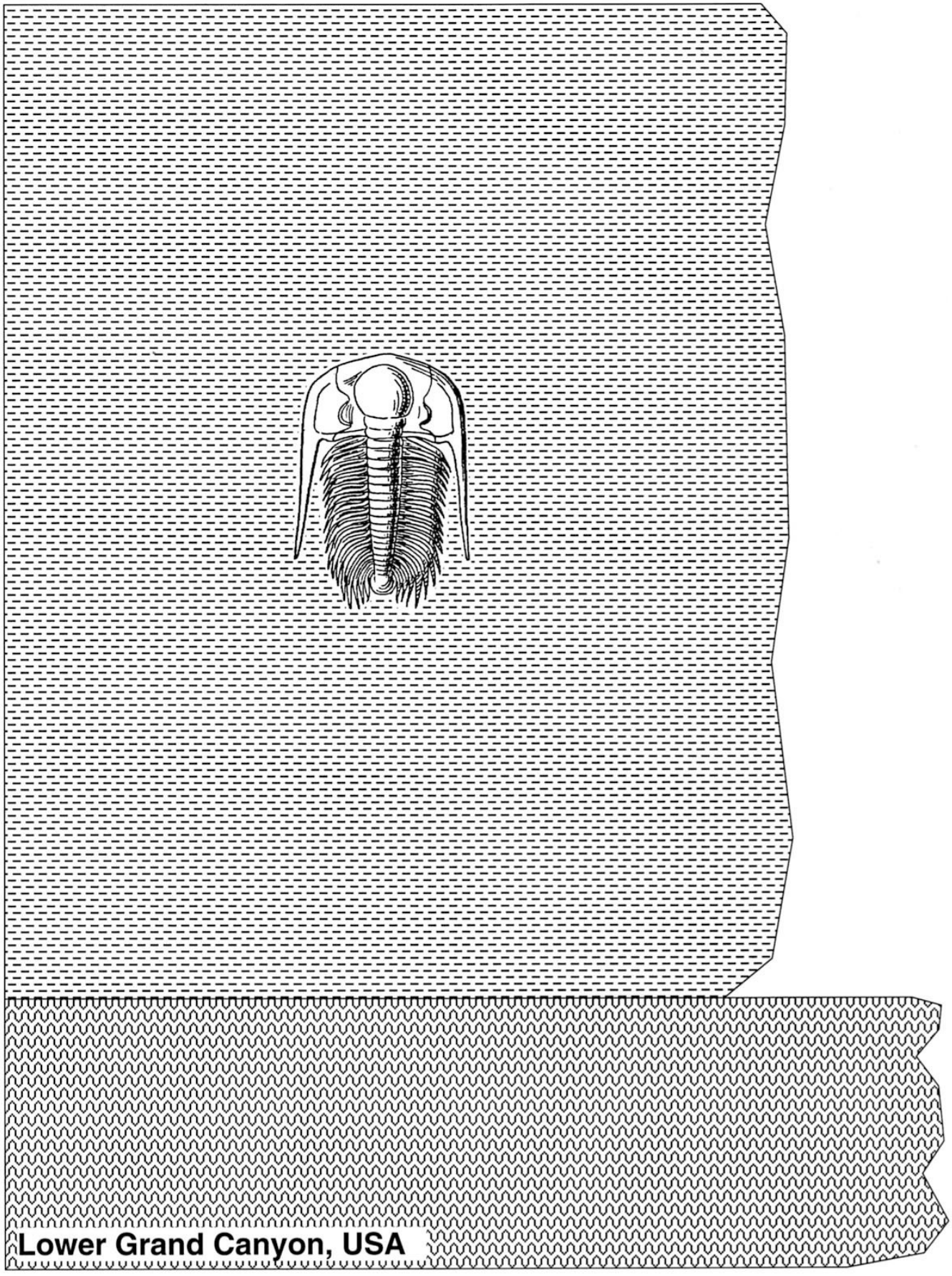
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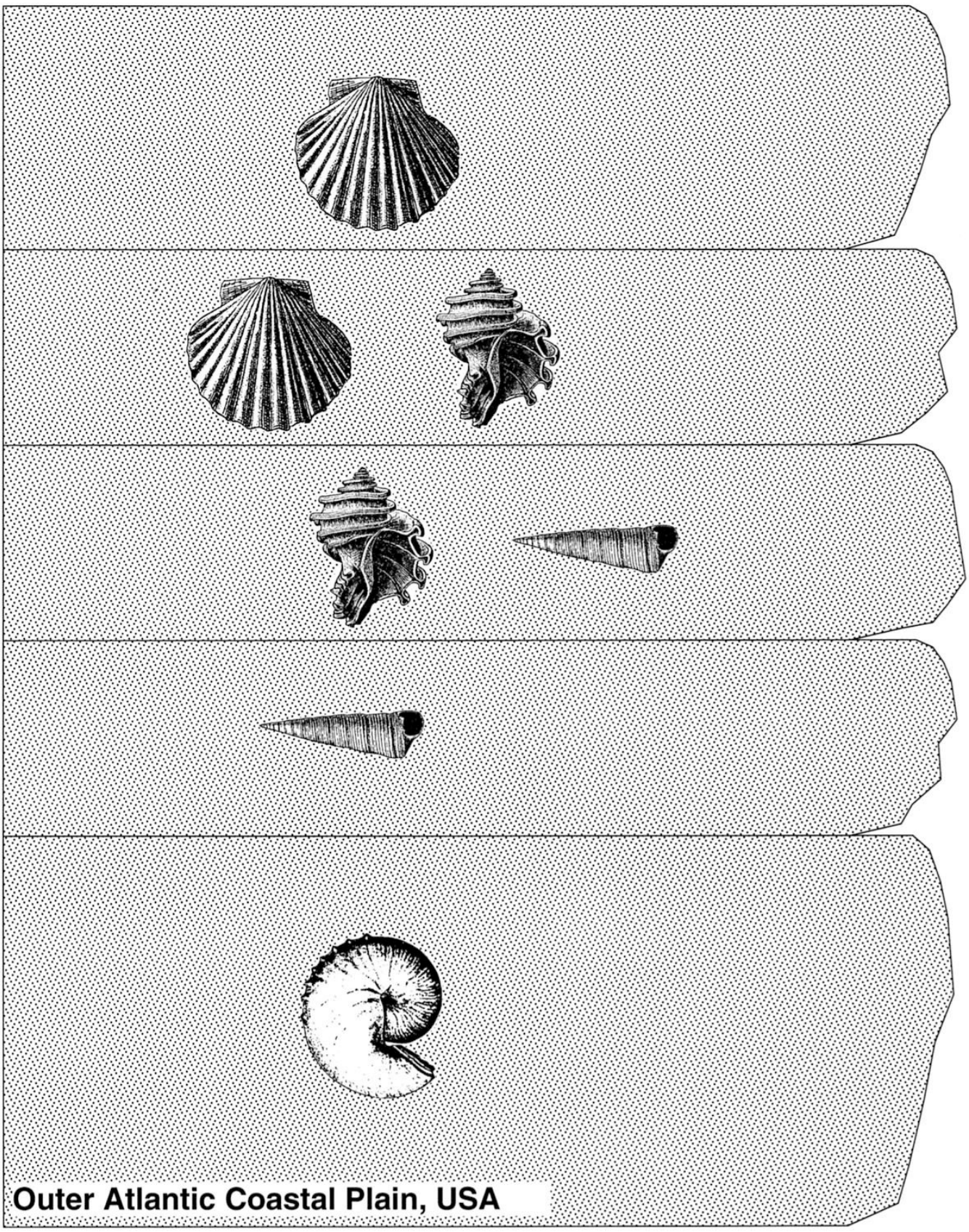
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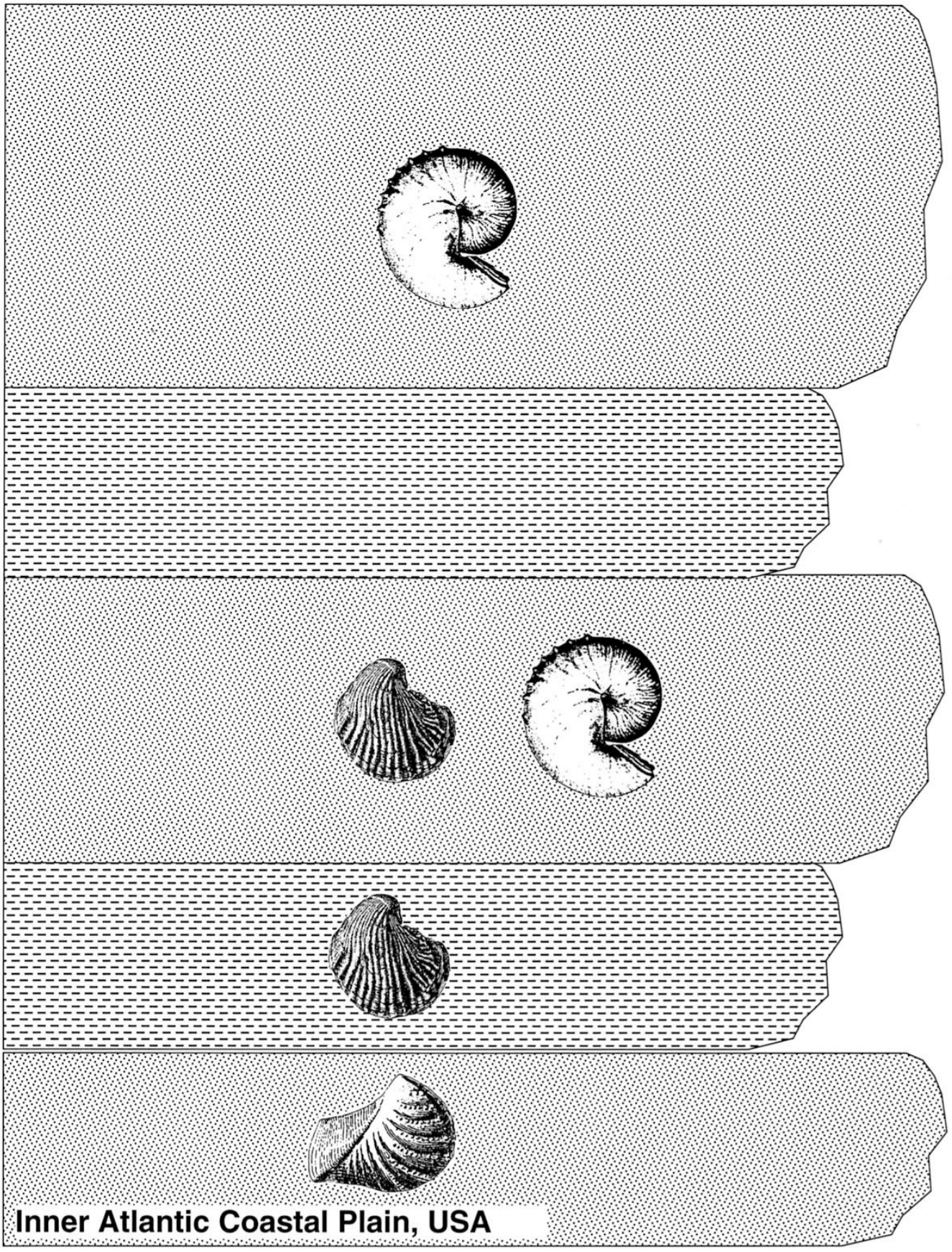
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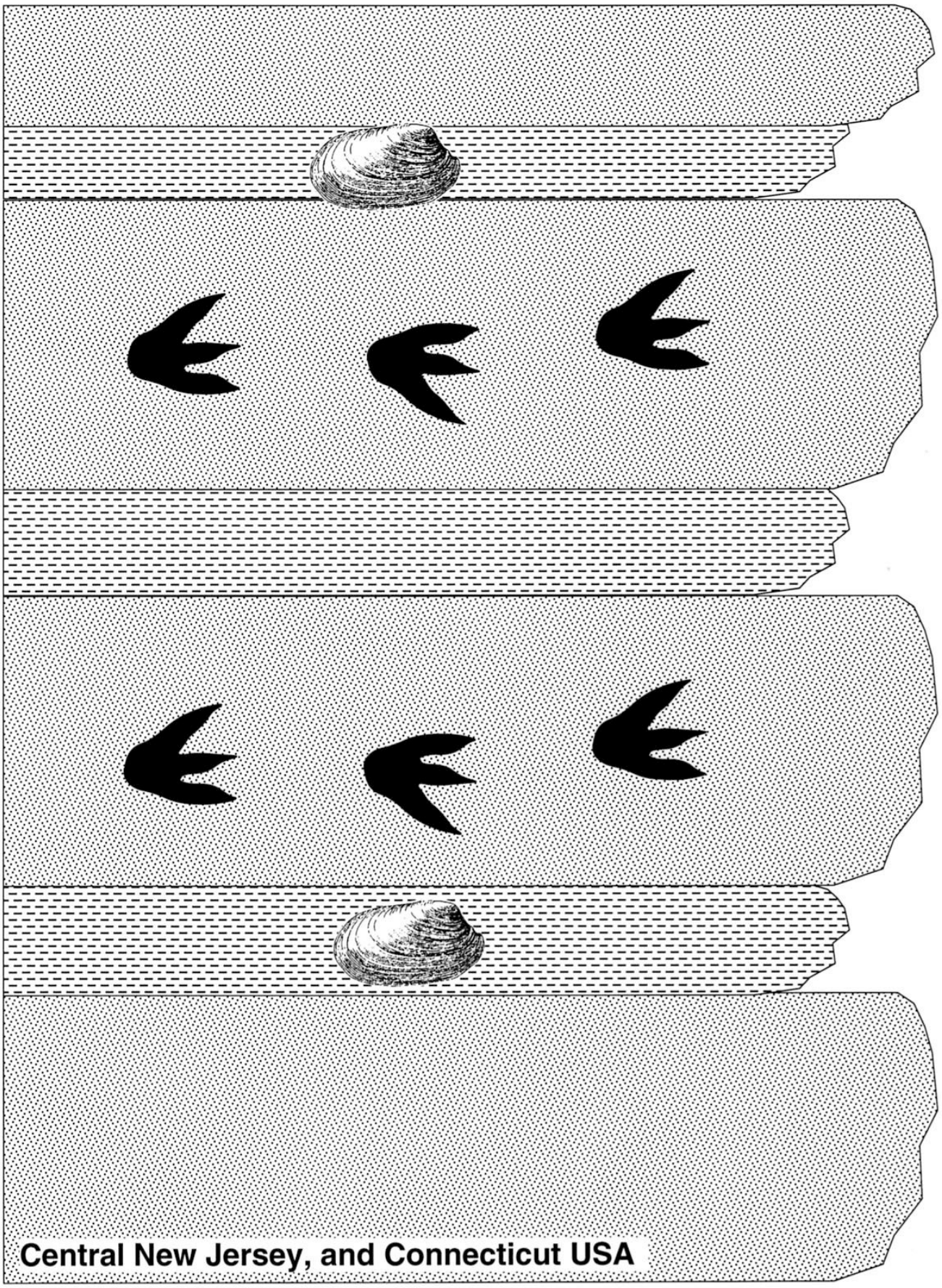
Central New Jersey, and Connecticut USA

Central New Jersey and Connecticut, USA

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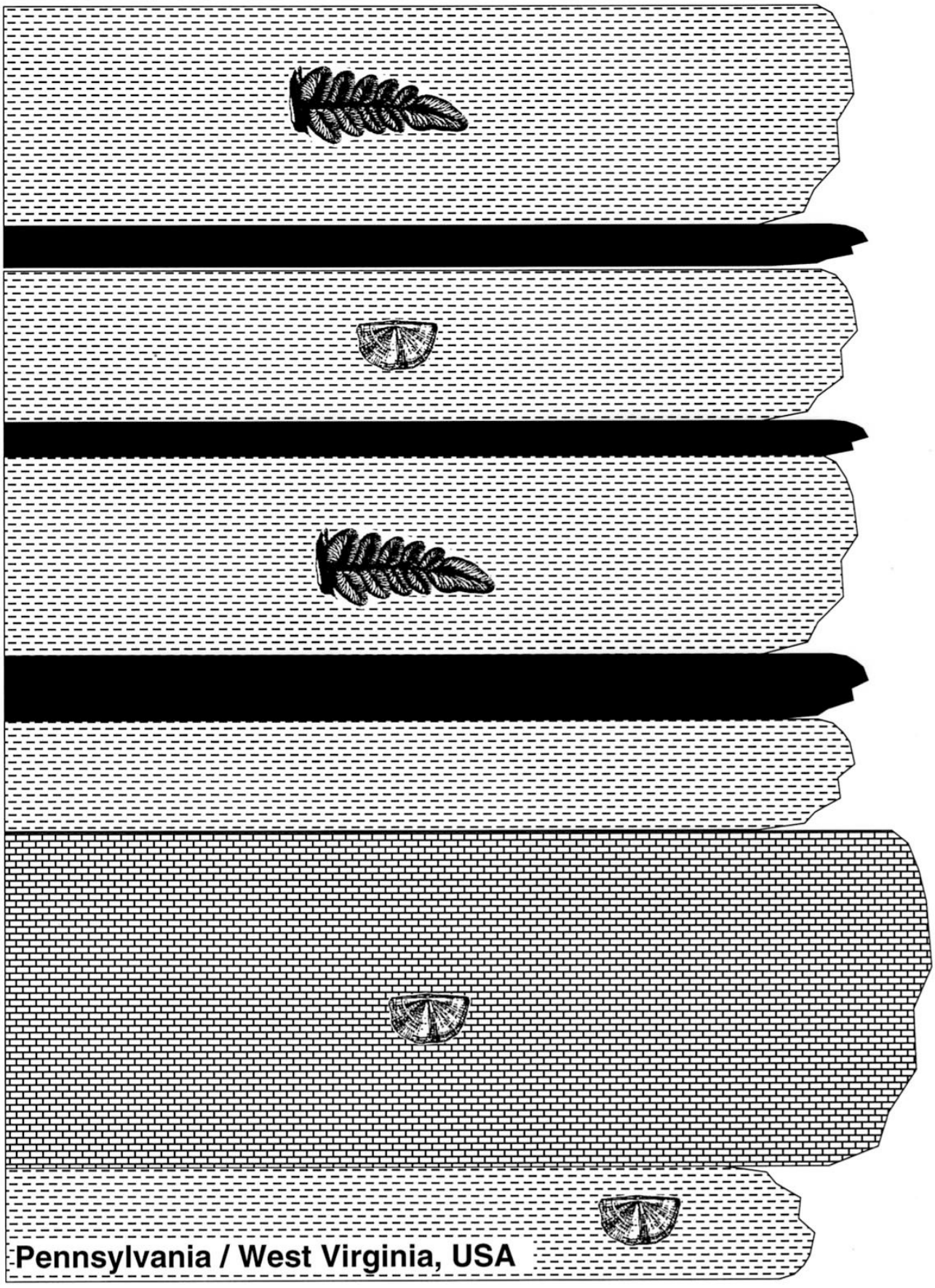
Pennsylvania / West Virginia, USA

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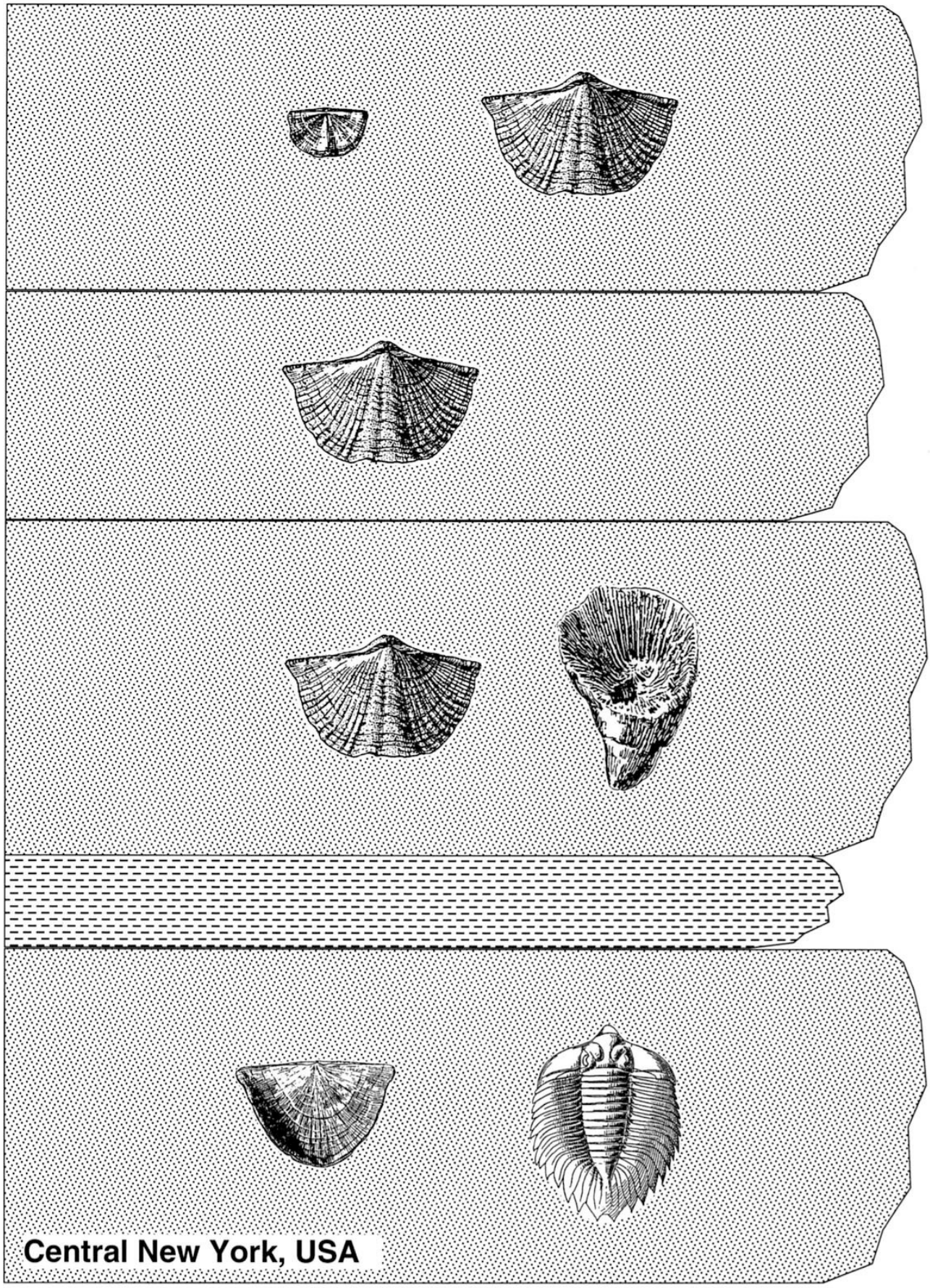
Central New York, USA

Central New York State, USA

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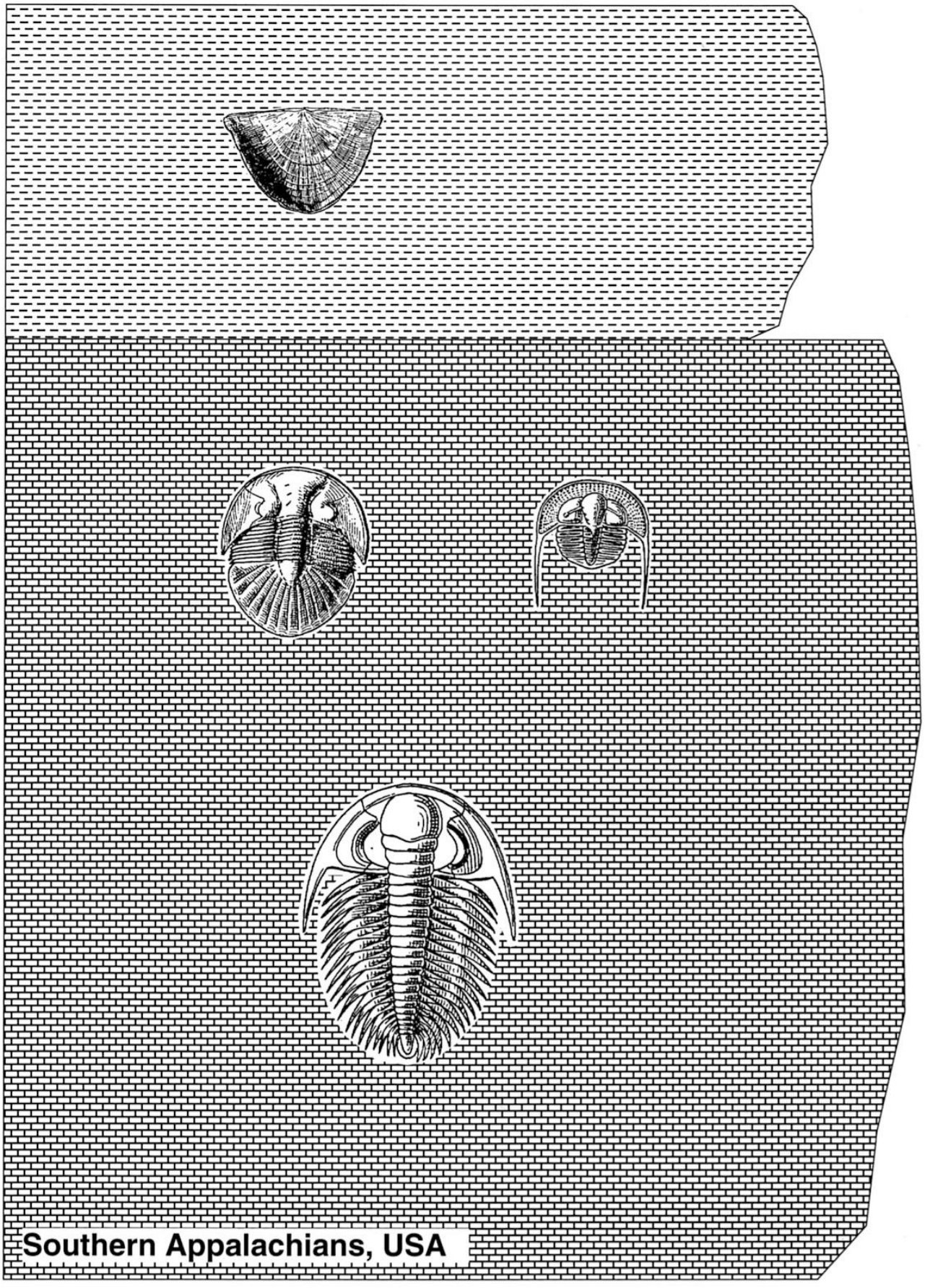
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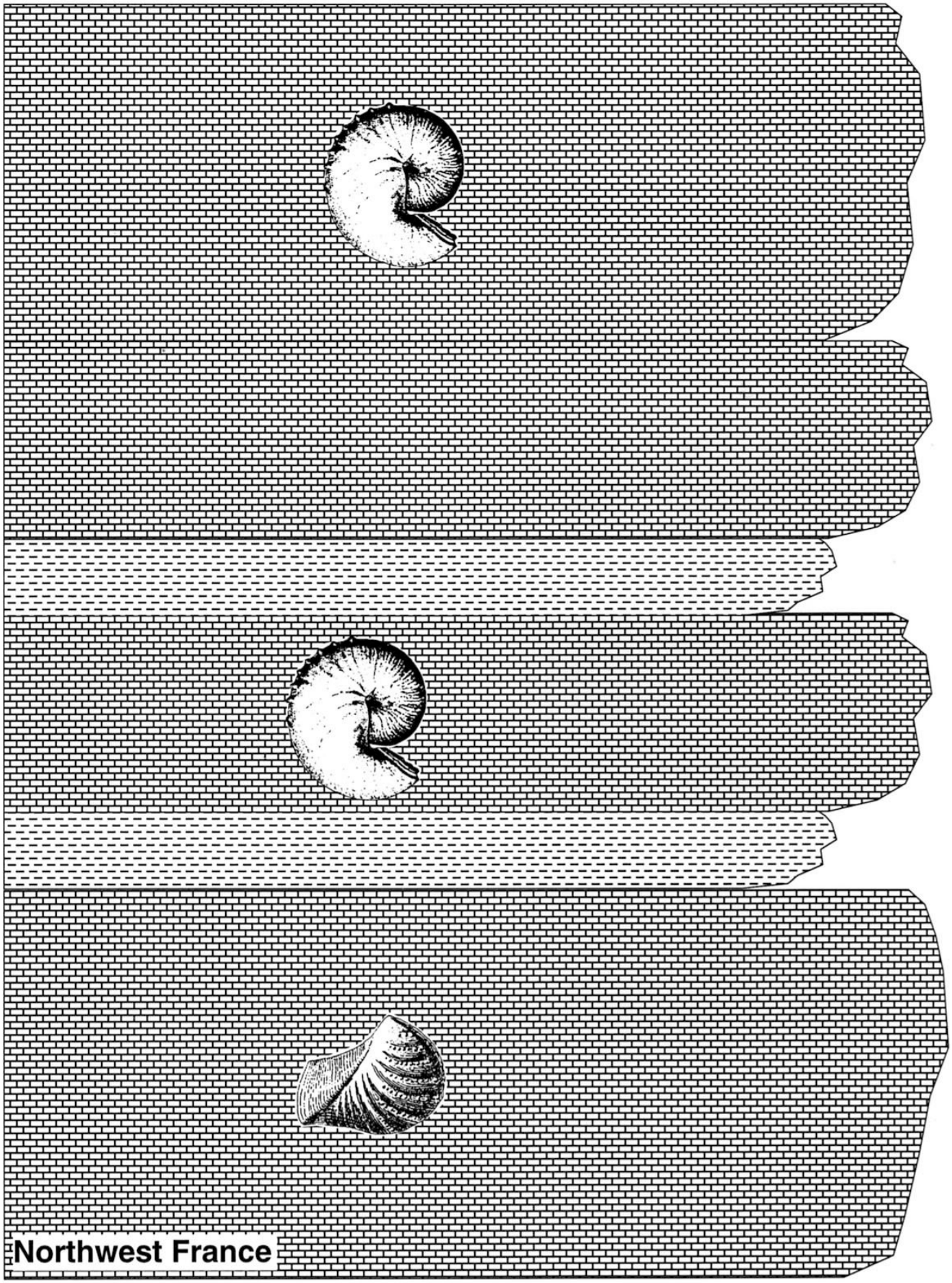
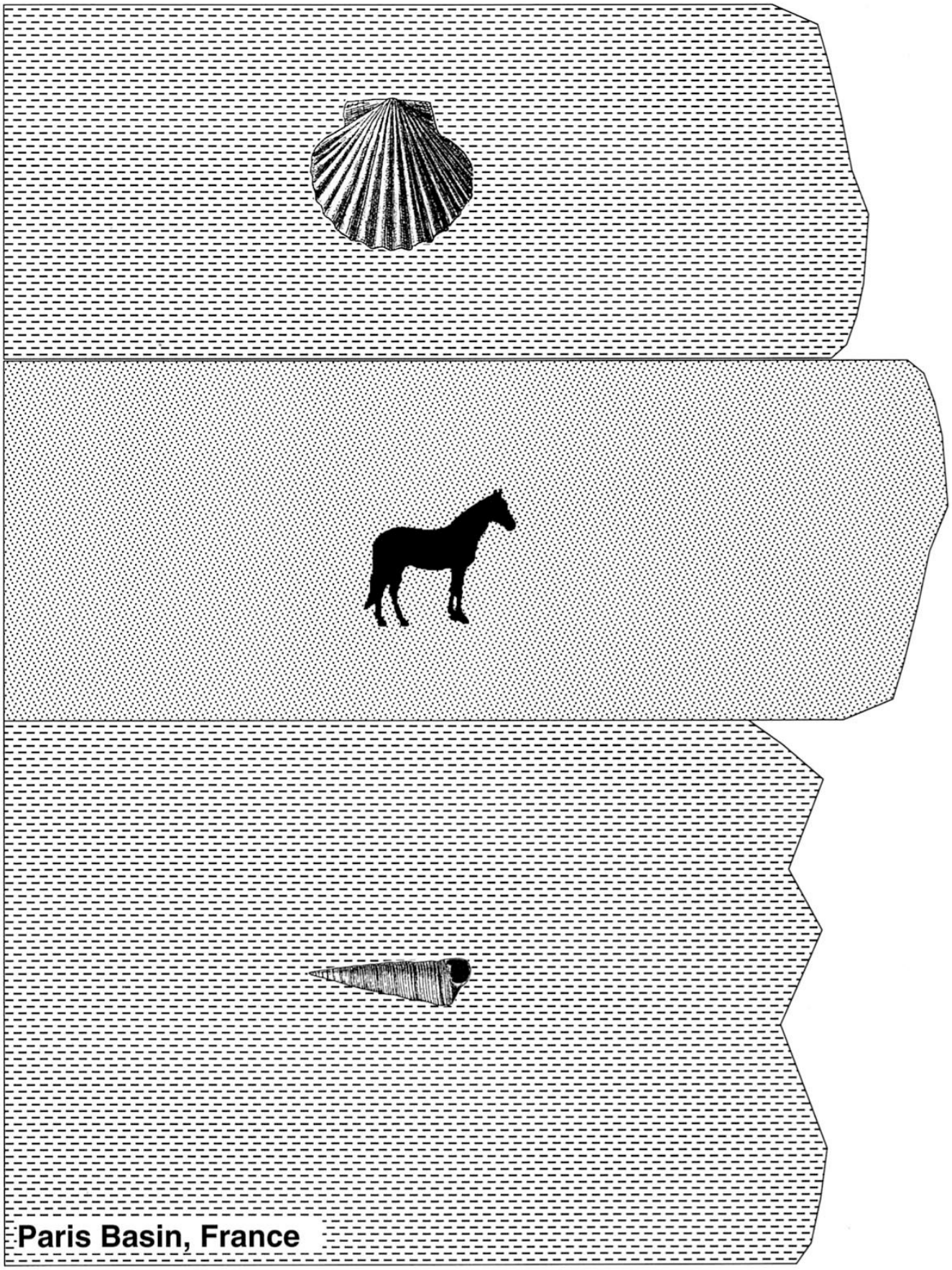

Northwest France

Northwestern France

In 1822, d'Omalius d'Halloy mapped and named the extensive chalk strata of southeast England, northwest France, and Belgium. He called these strata "Cretace" or Cretaceous, after the Latin word for chalk.


Paris Basin, France

Paris Basin

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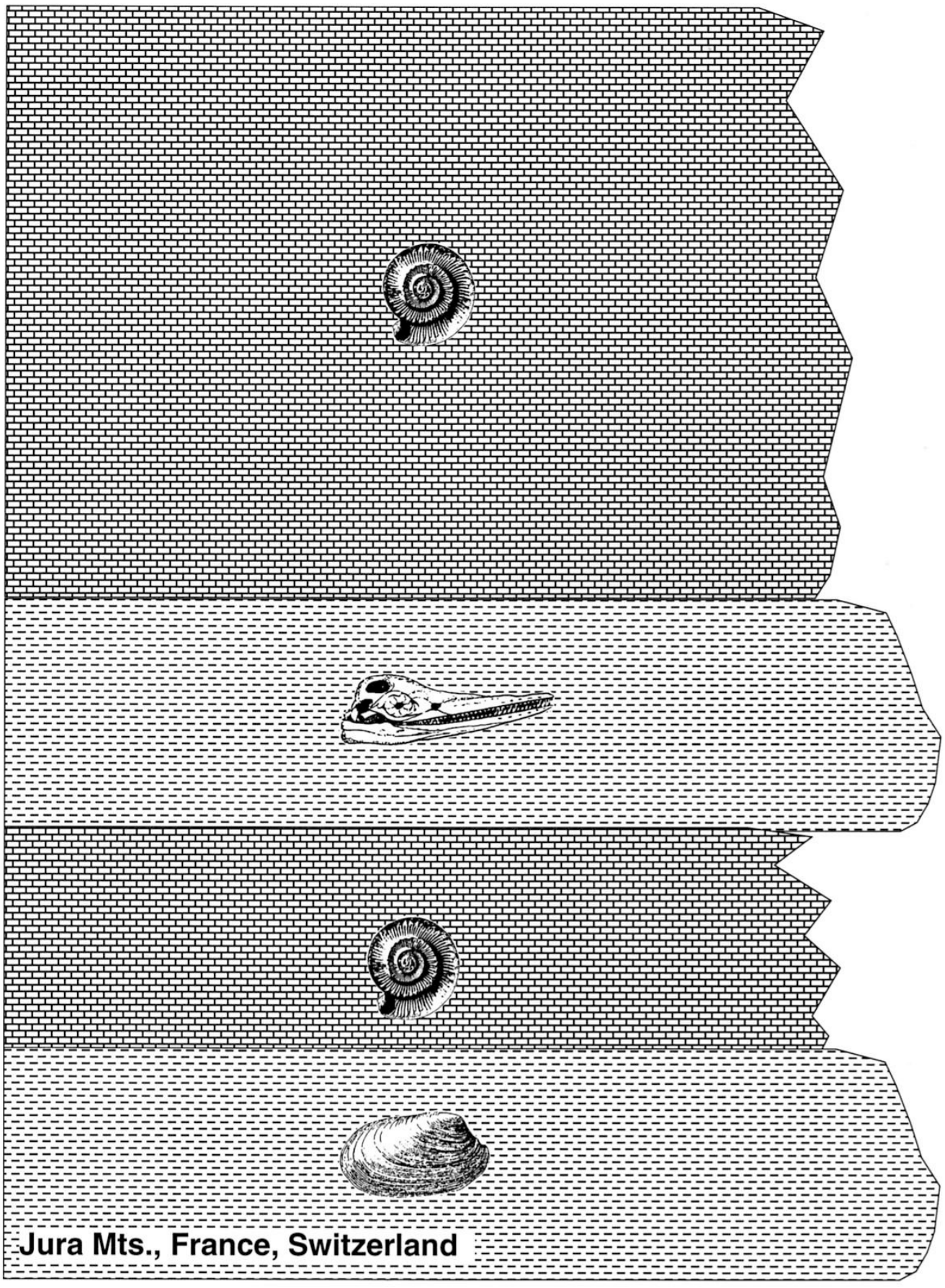
Jura Mts., France, Switzerland

Jura Mts. France and Switzerland

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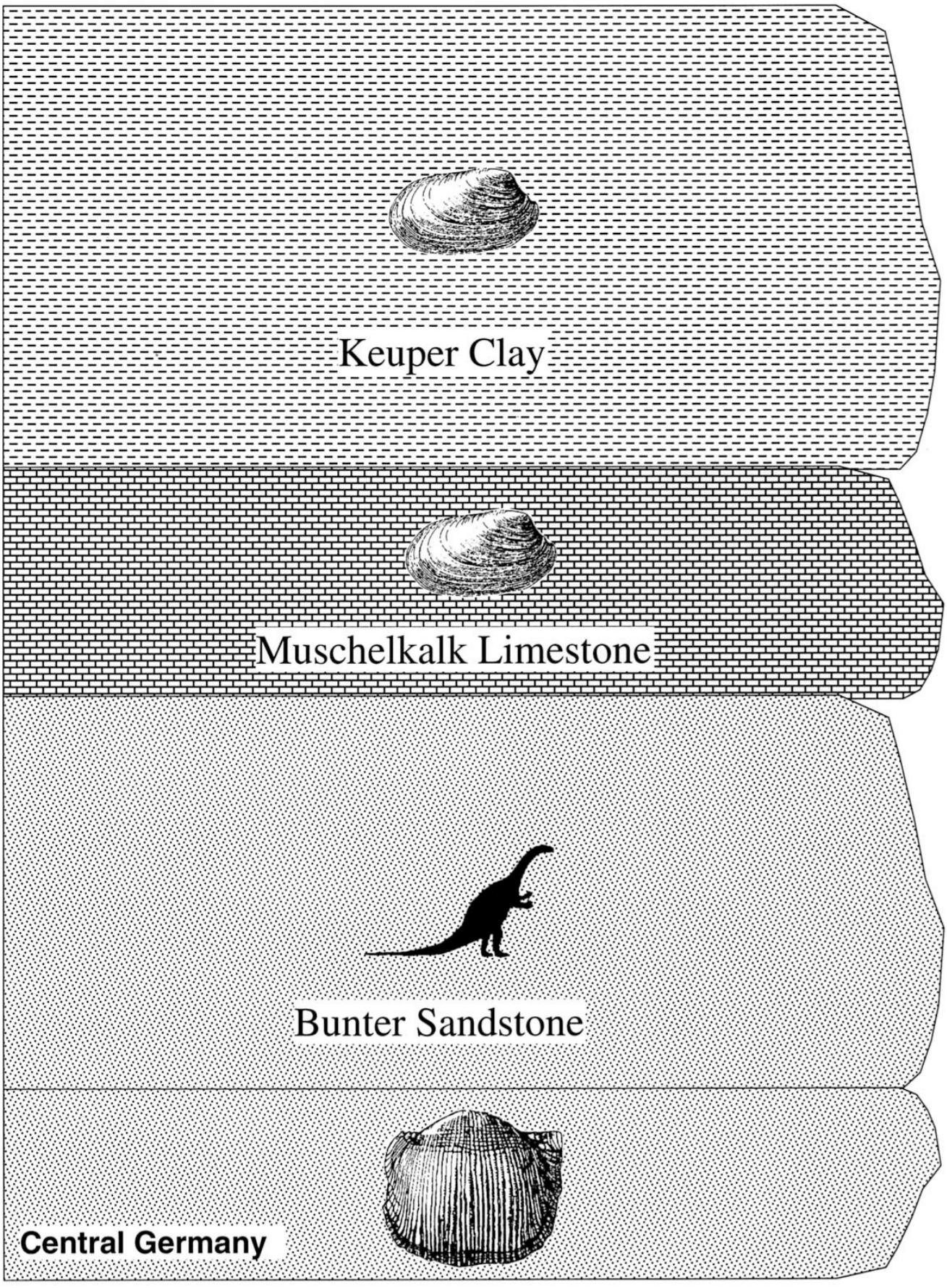
Keuper Clay
Muschelkalk Limestone
Bunter Sandstone
Central Germany

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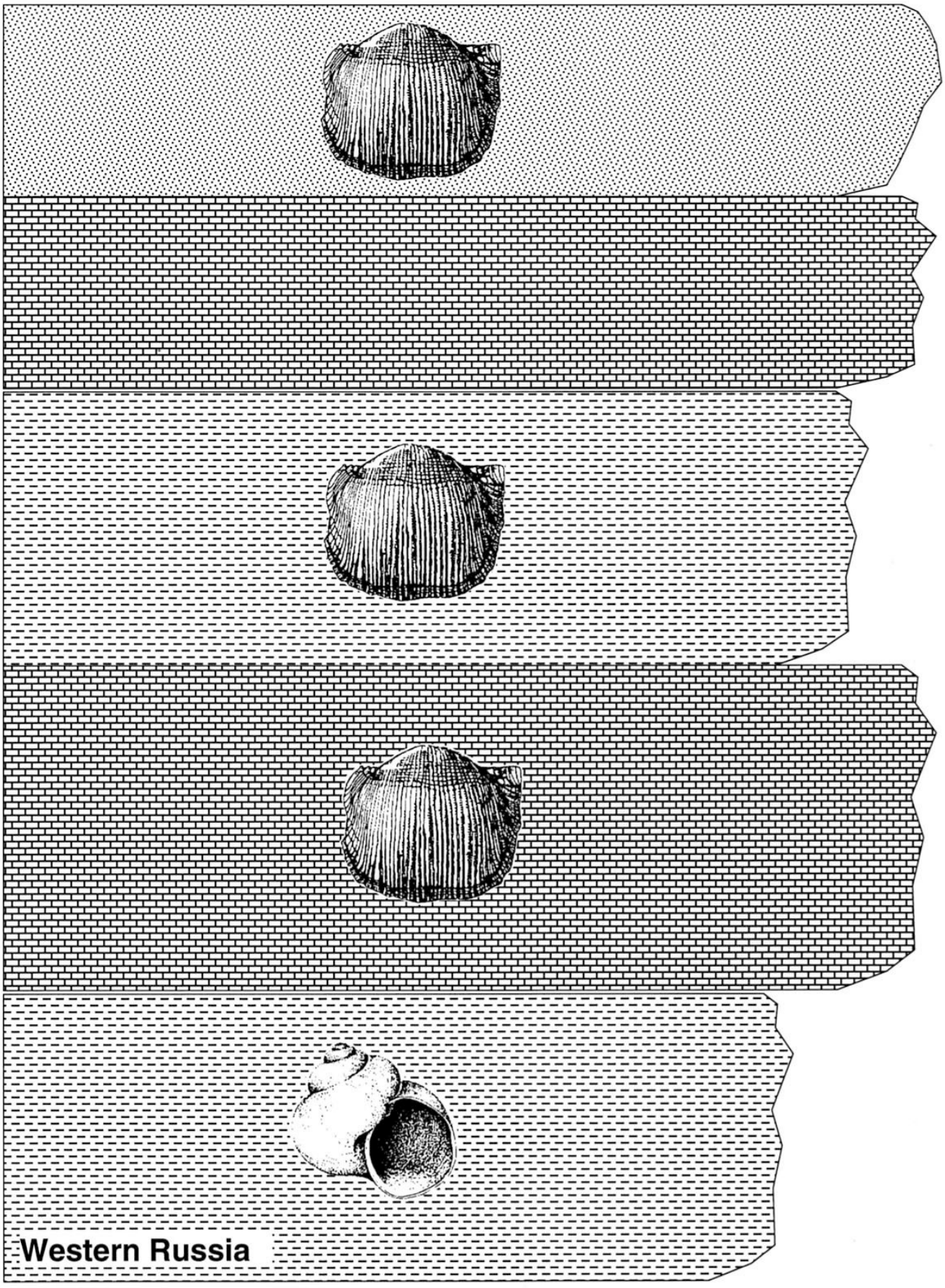
Western Russia

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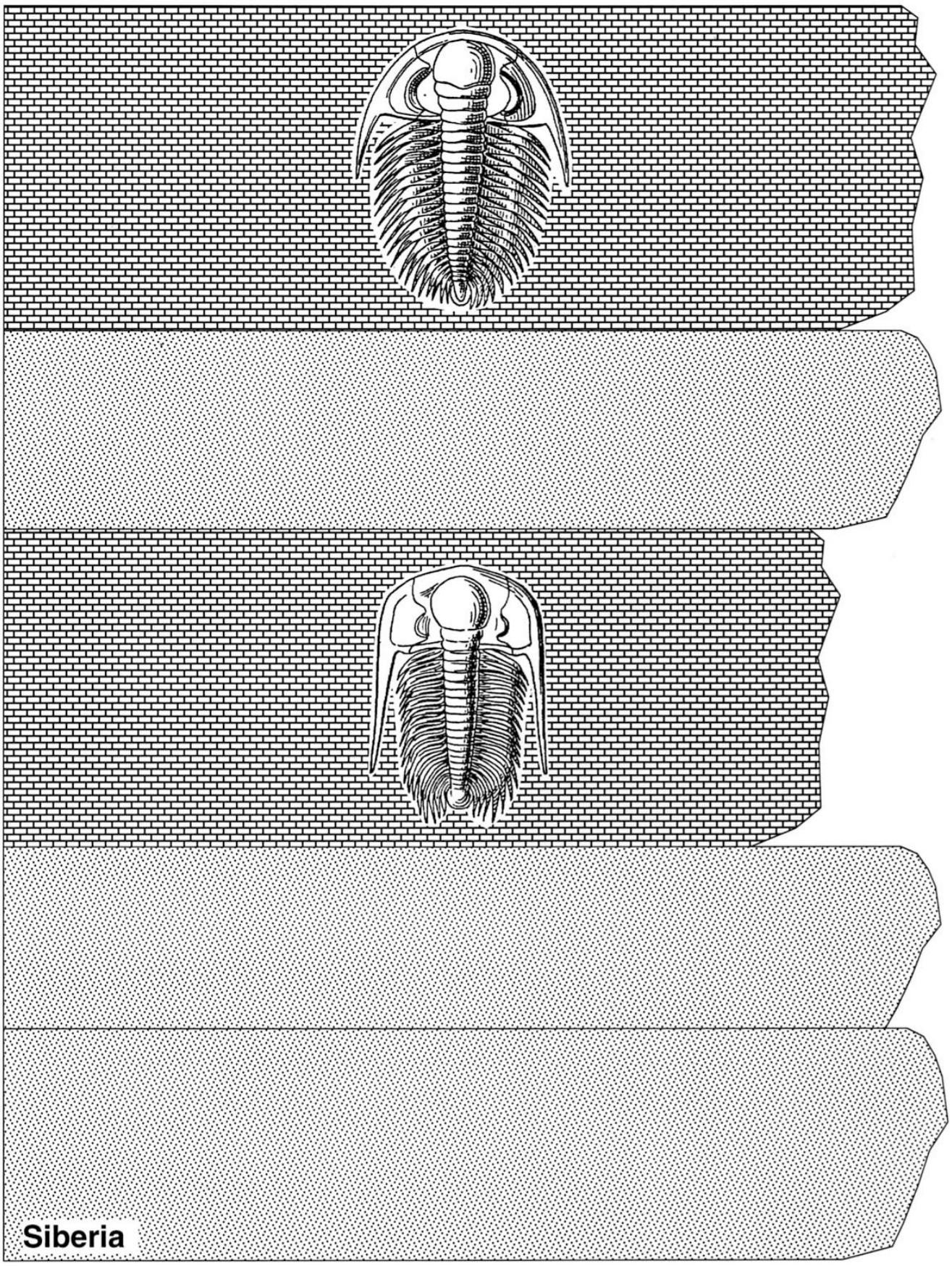
Siberia

Siberia

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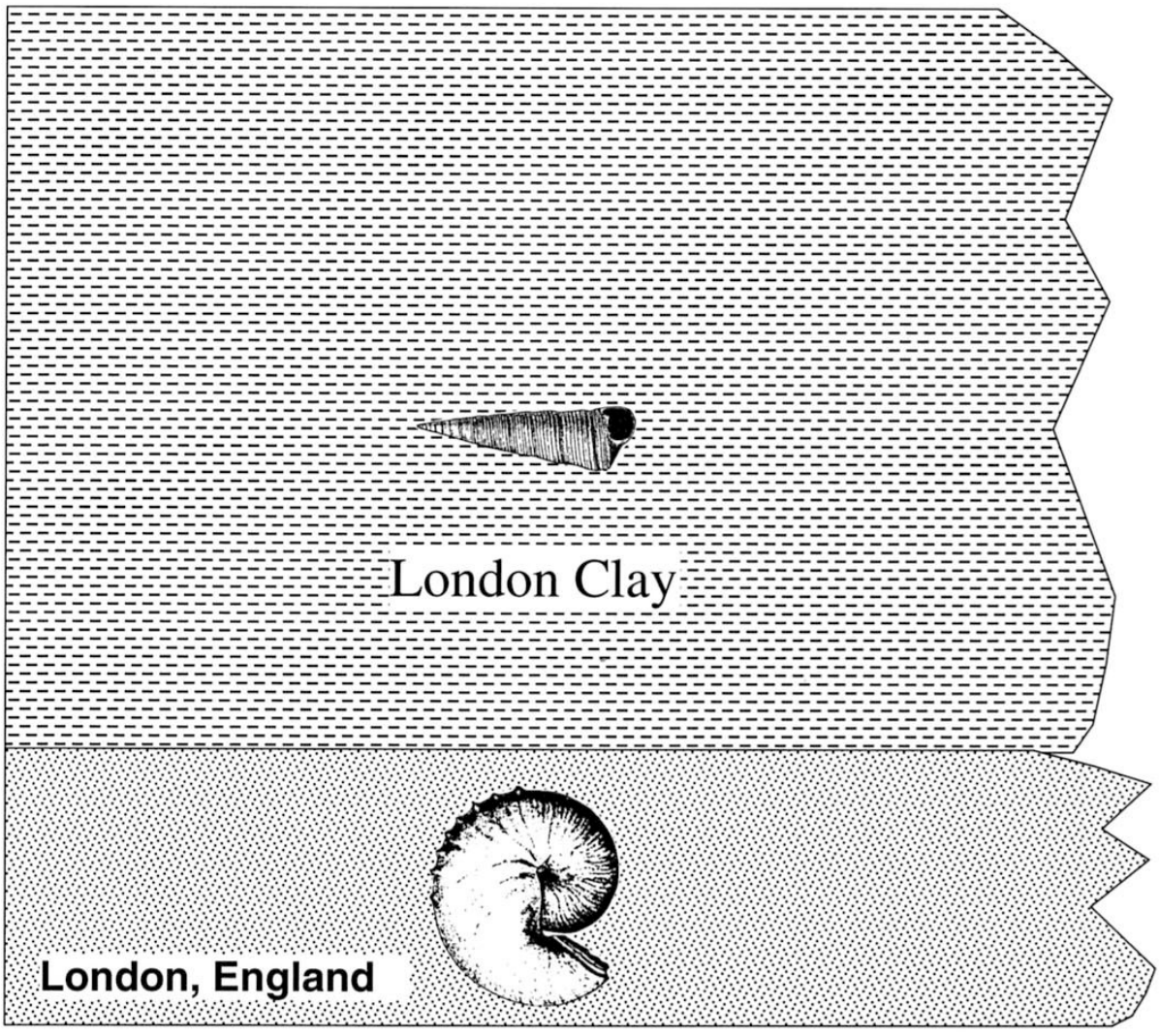
London Clay
London, England

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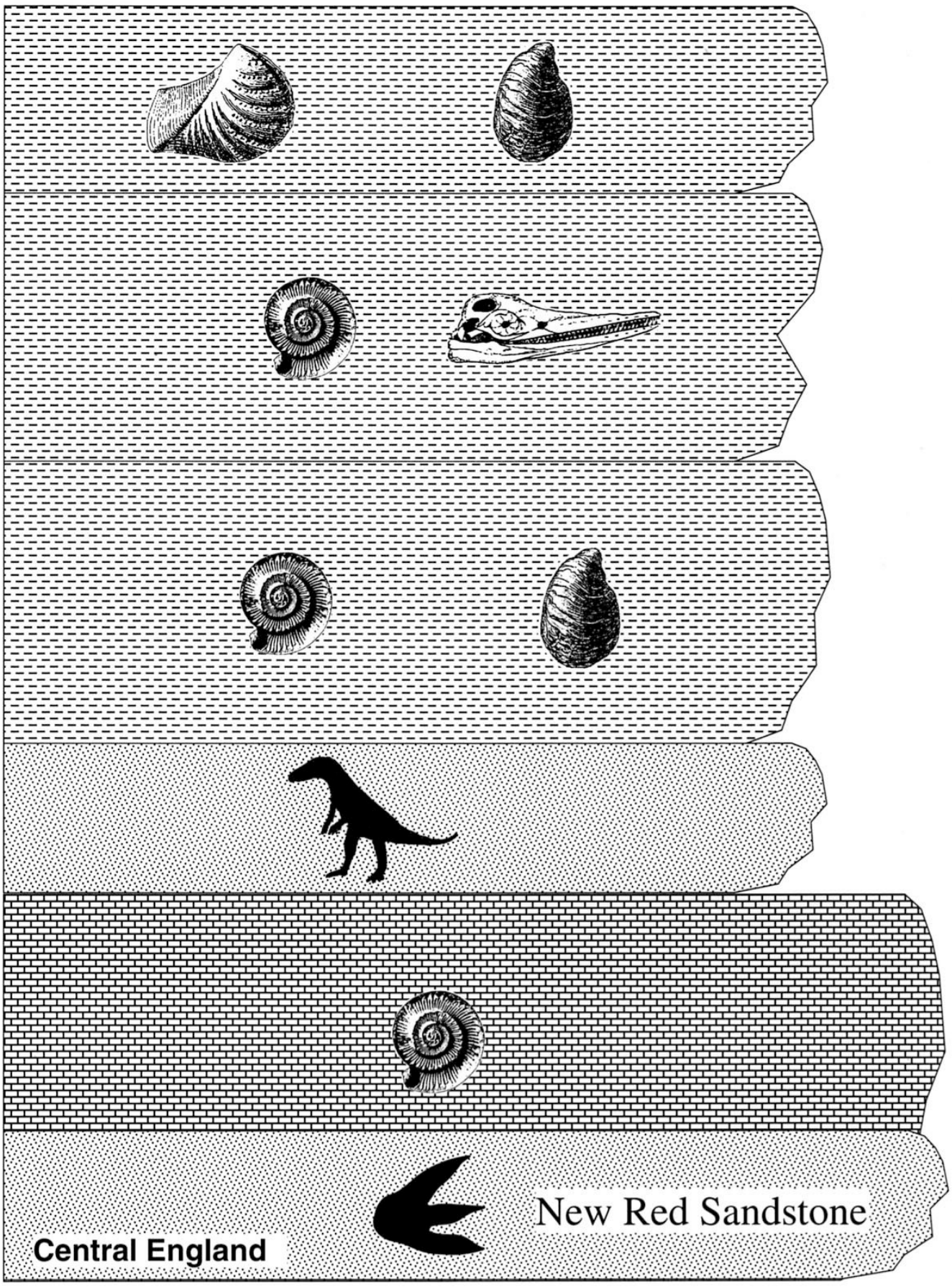
New Red Sandstone
Central England

Central England

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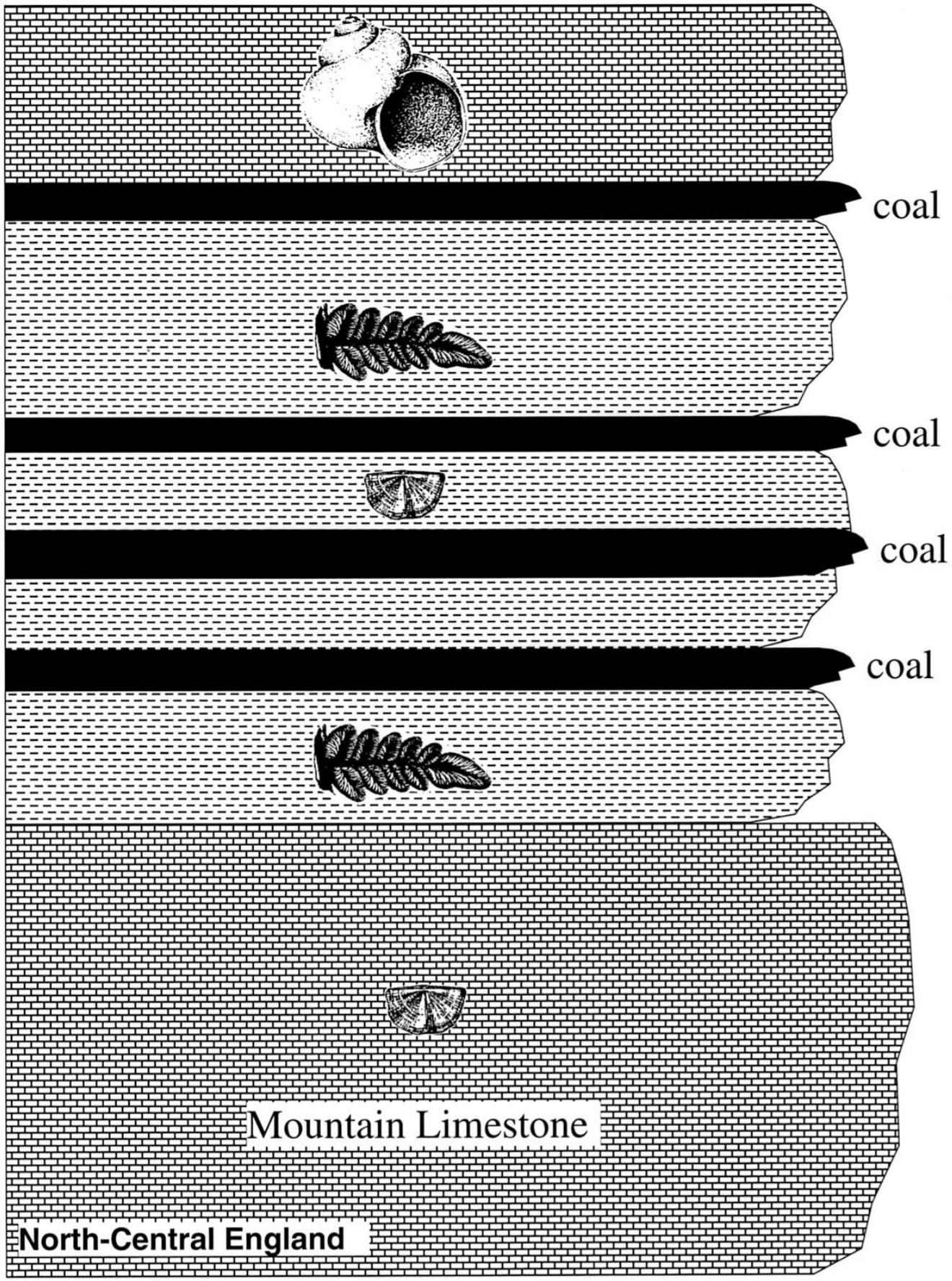
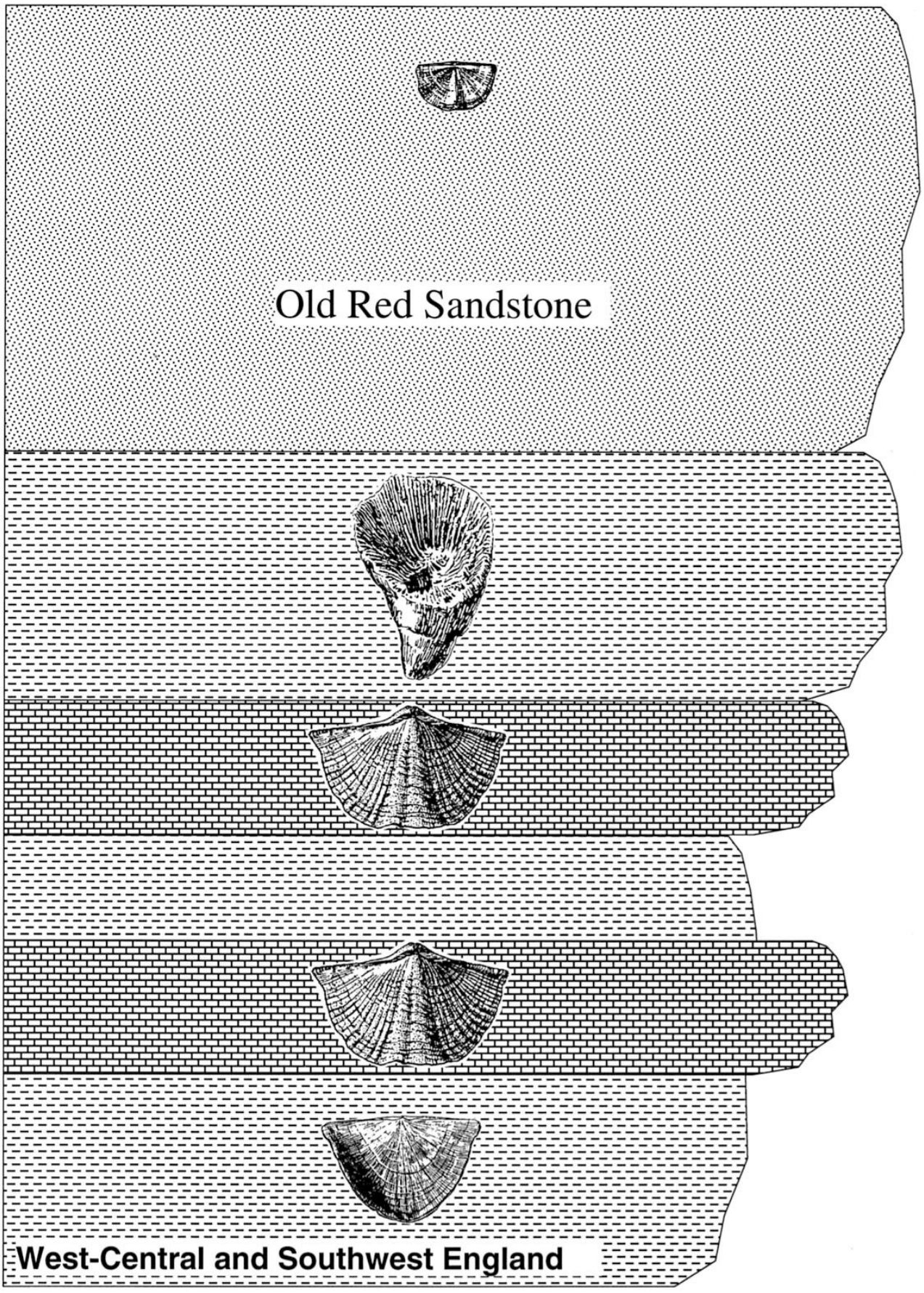

coal
coal
coal
coal
Mountain Limestone
North-Central England

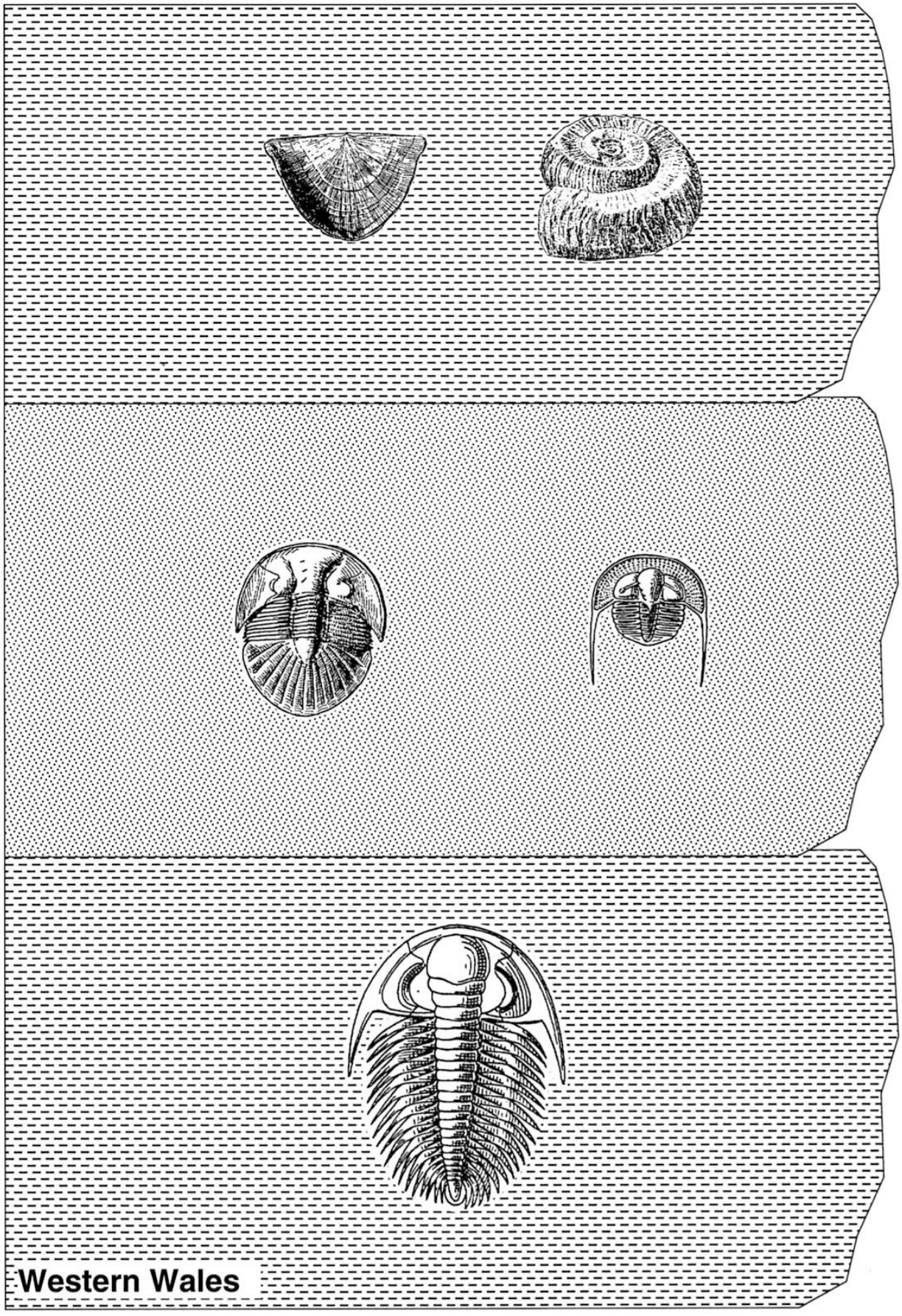
North Central England

The coal-bearing strata of north-central England were designated the "Carboniferous" by W. D. Conybeare and W. Phillips in their 1822 summary of the geology of Britain. Included with the coal-bearing strata in the Carboniferous was an underlying rock unit called the "Mountain Limestone".


Old Red Sandstone
West-Central and Southwest England

West Central and Southwest England

Originally, the "Old Red Sandstone" of west-central England was placed in the Carboniferous below the base of the Mountain Limestone. Studies in the late 1830's by Adam Sedgwick, Roderick Murchison, and John Phillips of folded layers in southwest England (Devonshire) showed that these rocks occupied the same position as the Old Red Sandstone (beneath the Carboniferous), but that they had their own, distinct types of fossils. They proposed the name "Devonian" in 1839 for these rocks that were intermediate between the Silurian below and the Carboniferous above.


Western Wales

Western Wales

In the 1830's, two men - Adam Sedgwick and Roderick Murchison - set out to map and describe the "transitional" strata of western Wales. Murchison worked from the top (below the Old Red Sandstone) down, Sedgwick worked from the bottom up, starting in North Wales. In 1835, Sedgwick named his sequence of strata the "Cambrian" after the Roman name for Wales and Murchison named the overlying sequence of strata "Silurian", after an ancient Welsh tribe. Later, in 1879, Charles Lapworth would show that a sequence of rock layers that overlapped between the bottom of Murchison's Silurian and the top of Sedgwick's Cambrian contained their own, distinctive kinds of fossils. Lapworth called these rocks "Ordovician" after the last of the British tribes to surrender to the Roman invasion.