Table 11.1 An exercise in recognizing evidence and drawing conclusions based on the writings of John Wesley Powell and the geology of the Grand Canyon

Four classroom-ready exercises are offered below. Each of the four versions of Table 11.1 provided offer a different focus as students identify evidence and make interpretations of that evidence. With version 1, students can interpret each of Powell's observations that are given in the table. With version 4, students are given Powell's interpretations and asked to cite the evidence (observation) on which each interpretation in most closely based. Versions 2 and 3 give students an opportunity to do a little of both interpretation and citing evidence. Students should engage in discussion and arguing from evidence as they interpret the Powell's work, and exact wording of the "answer" is less important than reasoned conceptual ideas.

.

Table 11.1

Example evidence-and-interpretation chart using John Wesley Powell's observations for student use, version 1.

From two simple ideas, superposition and crosscutting relationships, Powell inferred three incursions of the sea and two mountain-building events for the Grand Canyon region, as well as the geologically recent uplift of the Colorado Plateau and erosion of the canyon.

Unit	Observations	Powell's interpretations/conclusions—the implications of the evidence
Powell's unit A	Crystalline schist—made of metamorphosed sandstone and shale	
	Granite dikes in the schist	
	Unfolded granite dikes in the schist	
Erosional boundary	Unconformity between unit A and unit B cutting across granite dikes and Schist	
Powell's unit B	Layers of "hard vitreous sandstone" (Powell called this quartzite)	
	Lava dikes and sills cutting across the schist, the erosion surface between A and B, and the quartzites	
	Non-horizontal quartzite layers	
Erosional boundary	Unconformity between unit B and unit C.	
Powell's unit C	"Carboniferous" sedimentary layers	
	Horizontal "Carboniferous" rocks	
Grand Canyon	Deep canyon with the Colorado river cutting across units A, B, and C	The "Carboniferous" and other rocks were uplifted and the river eroded down through them.

Table 11.1

Example evidence-and-interpretation chart using John Wesley Powell's observations for student use, Version 2.

From two simple ideas, superposition and crosscutting relationships, Powell inferred three incursions of the sea and two mountain-building events for the Grand Canyon region, as well as the geologically recent uplift of the Colorado Plateau and erosion of the canyon.

Unit	Observations	Powell's interpretations/conclusions—the implications of the evidence
Powell's unit A	Crystalline schist—made of metamorphosed sandstone and shale	The layers of sandstone and shale were deposited in an ancient sea, followed by burial and mountain building that metamorphosed those layers.
	Granite dikes in the schist	
		Intrusion of magma occurred after the folding of the schist.
Erosional boundary	Unconformity between unit A and unit B cutting across granite dikes and schist	
Powell's unit B		Sandy sediments were deposited in another sea.
	Lava dikes and sills cutting across the schist, the erosion surface between A and B, and the quartzites	
		A second tectonic event—perhaps a mountain-building event—tilted the rocks after the deposition and burial of the layers of sandstone (quartzite).
Erosional boundary	Unconformity between unit B and unit C.	
Powell's unit C		A third sea invaded the region. (Unknown to Powell, there were several incursions of the sea during this time.)
	Horizontal "Carboniferous" rocks	
Grand Canyon		The "Carboniferous" and other rocks were uplifted and the river eroded down through them.

Table 11.1

Example evidence-and-interpretation chart using John Wesley Powell's observations for student use. Version 3.

From two simple ideas, superposition and crosscutting relationships, Powell inferred three incursions of the sea and two mountain-building events for the Grand Canyon region, as well as the geologically recent uplift of the Colorado Plateau and erosion of the canyon.

Unit	Observations	Powell's interpretations/conclusions—the implications of the evidence
Powell's unit A	Crystalline schist—made of metamorphosed sandstone and shale	The layers of sandstone and shale were deposited in an ancient sea, followed by burial and mountain building that metamorphosed those layers.
		Magma cooled at depth, not at or near Earth's surface—again suggesting presence of mountains.
	Unfolded granite dikes in the schist	
Erosional boundary	Unconformity between unit A and unit B cutting across granite dikes and schist	Mountains above the metamorphic and igneous rocks of unit A were eroded away after the formation of the dikes and schist.
Powell's unit B		Sandy sediments were deposited in another sea.
	Lava dikes and sills cutting across the schist, the erosion surface between A and B, and the quartzites	
	Non-horizontal quartzite layers	A second tectonic event—perhaps a mountain-building event—tilted the rocks after the deposition and burial of the layers of sandstone (quartzite).
Erosional boundary		The tilted layers of unit B were uplifted and eroded.
Powell's unit C	"Carboniferous" sedimentary layers	
		There have been no more tilting events since the Carboniferous* time.
Grand Canyon	Deep canyon with the Colorado river cutting across units A, B, and C	

Table 11.1

Example evidence-and-interpretation chart using John Wesley Powell's observations for student use. Version 4.

From two simple ideas, superposition and crosscutting relationships, Powell inferred three incursions of the sea and two mountain-building events for the Grand Canyon region, as well as the geologically recent uplift of the Colorado Plateau and erosion of the canyon.

Unit	Observations	Powell's interpretations/conclusions—the implications of the evidence
Powell's unit A		The layers of sandstone and shale were deposited in an ancient sea, followed by burial and mountain building that metamorphosed those layers.
		Magma cooled at depth, not at or near Earth's surface—again suggesting presence of mountains.
		Intrusion of magma occurred after the folding of the schist.
Erosional boundary		Mountains above the metamorphic and igneous rocks of unit A were eroded away after the formation of the dikes and schist.
Powell's unit B		Sandy sediments were deposited in another sea.
		Volcanic activity came after the seas and mountain-building events of unit A and after the deposition of the quartzite of unit B.
		A second tectonic event—perhaps a mountain-building event—tilted the rocks after the deposition and burial of the layers of sandstone (quartzite).
Erosional boundary		The tilted layers of unit B were uplifted and eroded.
Powell's unit C		A third sea invaded the region. (Unknown to Powell, there were several incursions of the sea during this time.)
		There have been no more tilting events since the Carboniferous* time.
Grand Canyon	Deep canyon with the Colorado river cutting across units A, B, and C	The "Carboniferous" and other rocks were uplifted and the river eroded down through them.