Sequence Stratigraphy

1. Introduction
2. Lithostratigraphy
3. Magnetostratigraphy
4. Biostratigraphy
5. Chronostratigraphy and Geologic Time
6. Marginal-Marine Environments
7. Siliciclastic Marine Environments
8. Carbonate and Evaporite Environments
9. Sequence Stratigraphy
10. Seismic Stratigraphy
11. Seismic Expression of Structural Styles

Grading

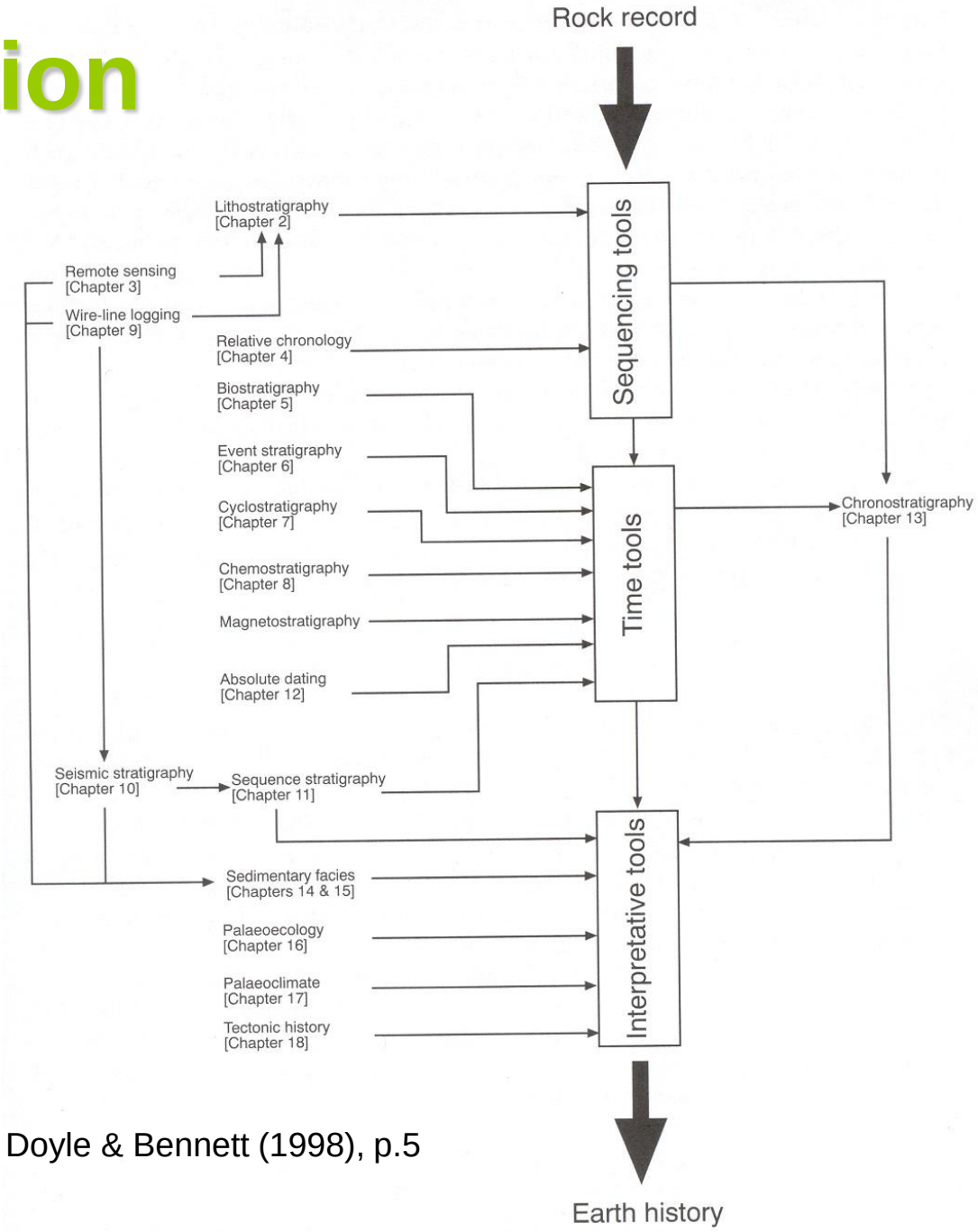
Midterm exam 40 %
Final exam 40 %
Homework 20 %

Textbooks

1. Bally, A. W. (eds.)., 1983. Seismic Expression of Structural Styles: A Picture and Work Atlas. AAPG Studies in Geology, 15. (Volumes 1 to 3)
2. Bally, A. W. (ed.). 1987. Atlas of Seismic Stratigraphy. AAPG Studies in Geology, 27. (Volumes 1 to 3)
3. Boggs, S., 2006. Principle of Sedimentology and Stratigraphy (4th ed.), Prentice-Hall, New Jersey, 662 p.
4. Catuneanu, O. (2006) *Principles of Sequence Stratigraphy*. Elsevier, 375 pp.
5. Coe, A. L., 2003. The Sedimentary Record of Sea-Level Change. Cambridge University Press, 287pp.
6. Shaw, J. H., Connors, C., Suppe, J., 2005. Seismic Interpretation of Contractional Fault-Related Folds. AAPG Studies in Geology, 53, 156 pp.

1. Introduction

Stratigraphy is the study of the stratified or sedimentary rocks: their nature, arrangement, and correlation from place to place. It enables geological events, as recorded in the rocks, to be placed in their correct sequence and is thus the key to the earth history.



Doyle & Bennett (1998), p.5

A brief history of the study of stratigraphy

☆ **John Strachey** (English, 1719) & **J. G. Lehmann** (German, 1756): Principle of superposition: The sedimentary rocks were laid down layer by layer. The upper layer, in an undisturbed section, must be younger than the lower.

☆ **Abraham Gottlob Werner** (A German civil engineer, late 1700s, Neptunist): He argued that almost all rocks (including igneous rocks) are formed by sedimentary processes, accumulating on the bottom of oceans, lakes or rivers.

☆ **James Hutton** (A Scottish medical doctor and farmer, 1726-1797, Plutonist): The founder of modern geology. He is sometimes referred to as the "Father of Geology". He made two important observations: (1) igneous origin for igneous rock (1785), and (2) Hutton's unconformity (1788), an angular unconformity in Scotland that separates Silurian marine strata below and Devonian continental strata above.

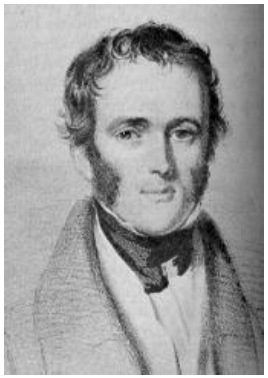
☆ **William Smith** (An English civil engineer, 1769-1839): He is sometimes referred to as the "Father of Stratigraphy". He laid the foundations of biostratigraphy by correlating rock unit using their fossil contents.

☆ **George Cuvier** (A French anatomist, 1769-1832): He and his co-workers, A. Brongniart and J. B. Elie de Beaumont, argued that catastrophic, sudden, but infrequent upheavals of mountain ranges were responsible for the environmental changes and the destruction of much of the contemporary biota. This idea is coined "catastrophism" (災變說).

☆ **Charles Lyell** (A British lawyer, 1797-1875, an Oxford graduate): He authored the "Principles of Geology" (1830-33). This book is sometimes read as the work that created the modern earth sciences, established their first "paradigm" or somehow "discover time". Lyell argued that causes that now visible around us (volcanoes, rivers, tidal currents, earthquakes, storms) are of the same kind that have acted in the past, and have done so with the same degree of intensity as in the present. This concept is coined "uniformitarianism" (均變說). In other words, the laws of nature are constant. This has sometimes been summarized by the catchphrase "the present is the key to the past".

William Smith

James Hutton



Charles Lyell

Hutton's unconformity

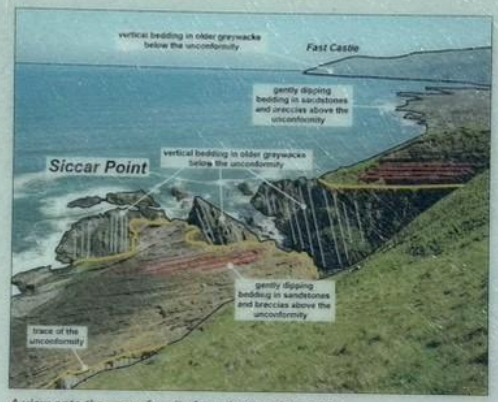
Siccar Point, Scotland

Hutton's unconformity

Siccar Point, Scotland

SICCAR POINT

James Hutton (1726-1797), known as the founding father of geology, was a man of genius. Whilst farming nearby he indulged in his passion for geology. The rocks here at Siccar Point were the defining proof for his revolutionary Theory of the Earth. Most people at this time thought the world no older than a few thousand years. Hutton realised that earth processes are cyclical and that geological time is virtually unlimited. What we see today is very much how he would have seen it over 200 years ago (but a moment in geological time!).



A view onto the unconformity from the top of the slope

SAFETY WARNING

The slope down to the unconformity is steep and dangerous. You do not need to go down to the shore to observe what these photographs illustrate.

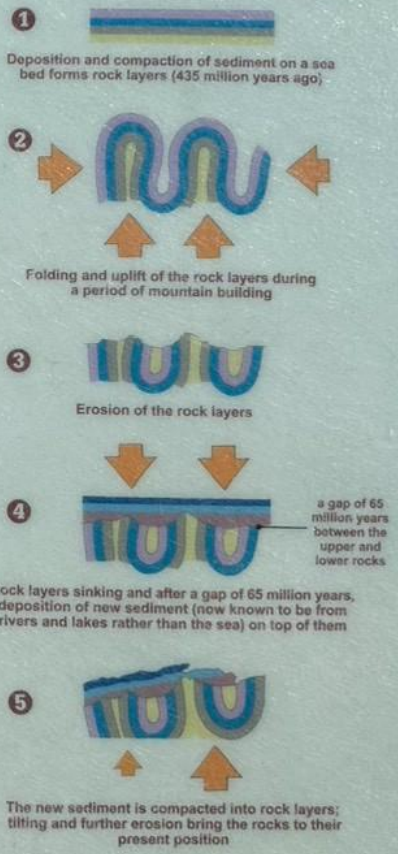
A close-up of the unconformity from the shore

The yellow lines mark the time gap between the underlying vertical rock layers (greyish in colour and called 'greywacke') and the overlying gently dipping rock layers, which are red sandstone and breccia (broken-up greywacke in a sandy matrix). The gap represents 65 million years.

During this time the underlying rocks, formed from layers of sediment deposited on the floor of an ancient ocean, had been folded, uplifted and eroded. This produced an uneven land surface onto which new sediment (sand and pebbles) was deposited, eventually forming sandstone and breccia. The irregular surface between the vertical and the gently dipping rock layers is known as an unconformity.

"Having taken boat at Dunglass Burn, we set out to explore the coast", writes James Hutton of his trip down the Berwickshire coast with his friends John Playfair and James Hall from nearby Dunglass, to find the proof for his theory...and this they did. *"At Siccar Point"* he wrote *"...we found a beautiful picture of this junction washed bare by the sea"*. John Playfair, deeply moved by the significance of what they observed wrote later *"The mind seemed to grow giddy by looking so far into the abyss of time"*.

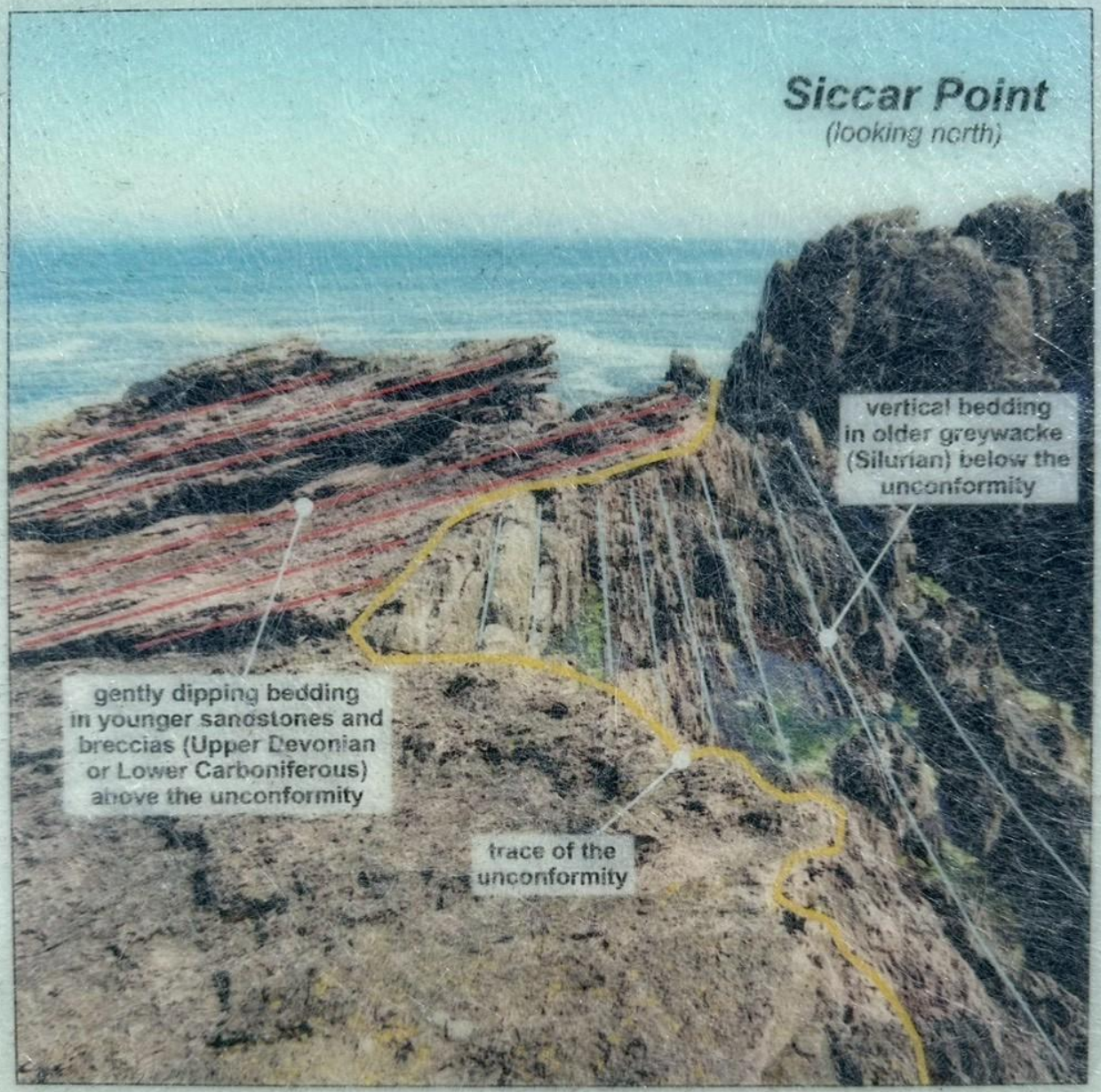
HOW THE UNCONFORMITY WAS FORMED



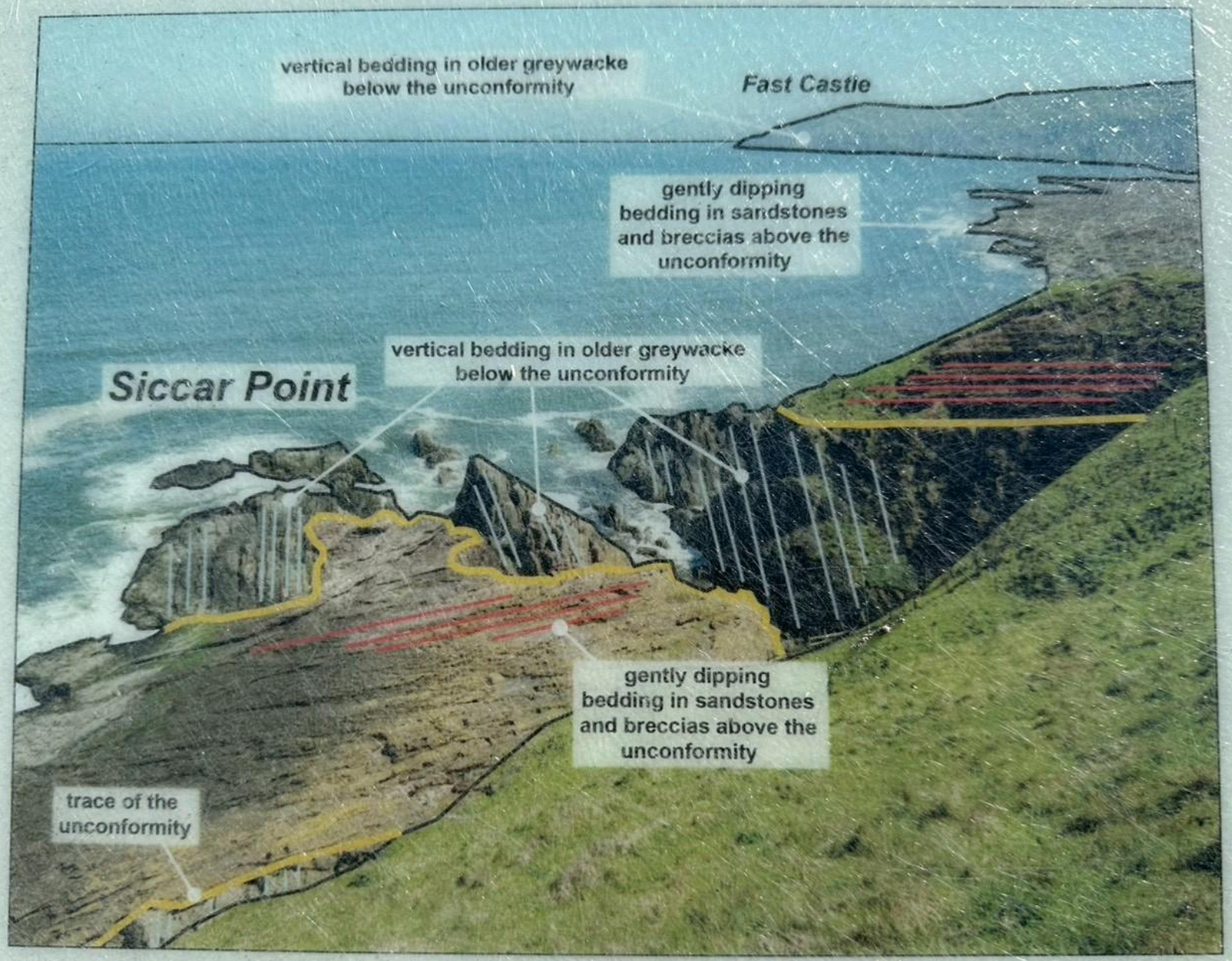
The Scottish Borders James Hutton Trail was initiated by BFRS in 2008 and implemented in partnership with local farmers, with public and private funding. New editions of these boards were produced in 2018, supported by Siccar Point Energy and the Edinburgh Geological Society.

PROJECT PART FINANCED BY THE EUROPEAN UNION

British Geological Survey



A close-up of the unconformity from the shore



A view onto the unconformity from the top of the slope

Disciplines of stratigraphy

Lithostratigraphy (岩石地層學)

Lithostratigraphy is the reco gnition, subdivision, and correlation (establishing equivalency) of sedimentary rocks on the basis of their lithology.

Biostratigraphy (生物地層學)

Biostratigraphy is the characterization and correlation of rock units on the basis of the fossils they contain.

Chronostratigraphy (時代地層學)

Chronostratigraphy is the unifying construct that defines (ideally by international agreement) boundaries for systems, series, and stages. Its ultimate product is the global stratigraphical column in which every moment of Phanerozoic time is represented by strata which by their contained fossils are distinct from those above or below.

Magnetostratigraphy (磁性地層學)

Magnetostratigraphy is the application of the chronology of reversals in polarity of the geomagnetic field to the study of the stratigraphy of to layered materials (i.e. sedimentary and volcanic rocks).

Seismic Stratigraphy (震測地層學)

Seismic stratigraphy is the study of seismic data for the purpose of extracting stratigraphic information.

Sequence Stratigraphy (層序地層學)

Sequence stratigraphy is the subject that is concerned with the large-scale, three-dimensional arrangement of sedimentary strata and with the major factors that influence their geometrical relationship. The basic conceptual unit, a “depositional sequence”, is a package of sedimentary strata bounded above and below by major surfaces. These surfaces are erosion surfaces (“unconformities”) along some of their length, and are technically defined as the “sequence boundaries”.