Readings:

For all papers (in advance):

1. What two things did you find most confusing?
2. What two things did you find most interesting?

Week 2:

FRODEMAN, R. 1995. Geological reasoning: Geology as an interpretive and historical science. Geological Society of America Bulletin, 107(8):960-968.

GOULD, S. J. 1965. Is uniformitarianism necessary? American Journal of Science, 263(3):223-228.

SHEA, J. H. 1982. Twelve fallacies of uniformitarianism. Geology, 10(9):455-460.

Group questions

1) Gould 1965. P. 225: Dawson (1894, p. 106) writes: "…while the laws of nature and the operations under them have been uniform in kind, we must beware of supposing that they have been uniform in rate".
   a) What are average rates of geologic processes and what is the variation of these rates?
   b) How do these plot in a time/space graph?
2) How do current textbooks in geology/earth science describe the concept of uniformitarism?
   a) Do they exhibit any of the fallacies described by Shea?
3) Frodeman 1995
   a) Go through text and produce a glossary of the concepts discussed
   b) We will produce a "concept map" of the ideas.

General discussion

should the concept of uniformitarism be taught? If yes, how?

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Week 3

SADLER, P. M. 1981. Sediment accumulation rates and the completeness of stratigraphic sections. Journal of Geology, 89(5):569-584.

KOWALEWSKI, M., G. A. GOODFRIEND, AND K. W. FLESSA. 1998. High-resolution estimates of temporal mixing within shell beds: the evils and virtues of time-averaging. Paleobiology, 24(3):287-304.

Sadler 1981 Group questions

1) P. 570 - There are four modes in Figure 1a. What is their probable origin and give examples (can be conceptual) of each.
2) How do maximum and minimum thicknesses and maximum and minimum rates vary among the environments in Figures 1-5? Put in a table.
3) What does Figure 8 indicate about the nature of the geological time scale? Using the current time scale, replot the graph.

General discussion questions:

1) What does it mean that sedimentation rates follow a log-normal distribution? What does this suggest about the processes?
2) P. 572. Why could these results be interpreted as indicating that sedimentation rates have increased over geologic time?
3) How does sedimentation occur in the 5 different environments and how might this explain the differences among the graphs?
4) P. 574 "discontinuities exist at all scales and …sections that which span longer time intervals have the opportunity to incorporate more and longer hiatuses." How does the Grand Canyon illustrate this?
5) A 100 meter sequence of sediment is deposited over 1 million years. The estimated sedimentation rate for that environment is 1m/1000 years. How complete is the section on the 1000 year time scale? Would it be more or less complete on the 10,000 year time scale?

Kowalewski et al. 1998.Group questions:

1) Figure 2. Describe the types of data used to generated this figure. Are their any uncertainties? What is the significance of "pre-bomb"
2) Figure 3. What is analytical time-averaging? What does this graph indicate about it? What does it imply for dating geologic collections?
3) Figure 4. What are the "take home" messages of this figure? What would you use as the best age estimate for each chenier?

General discussion questions:

1) What are the implications of these results to our ability to resolve ecological processes in the fossil record?
2) How do these results relate to the incompleteness concept of Sadler?
3) P. 296. Why will both single shells and bulk collections tend to overestimate the age of a deposit?

Week 4

MARSHALL, C. R. 1997. Confidence intervals on stratigraphic ranges with nonrandom distributions of fossil horizons. Paleobiology, 23(2):165-173.

SADLER, P. M. 2008. Quantitative biostratigraphy - Achieving finer resolution in global correlation. Annual Review of Earth and Planetary Sciences, 32:187-213.

Marshall 1997: General discussion

1) What are the terms used in equations 3 and 5? How they expressed in Figure 1?

Sadler 2008: General discussion

1) Figure 2. Page 192.
   a) Part A shows the actual history. What are the features of the history?
   b) How are these aspects of the history preserved in the sections X, Y, Z, and W?
2) P. 193-194. We will use FAD and LAD to refer to the true global first and last occurrence.
   a) Can a local lowest find (bottom) be adjusted down? Up?
   b) Can a local highest find (top) be adjusted down? Up?

3) P. 193-194. Two taxa do not overlap in a local section. Let Y be the upper taxon and Z the lower.
   a) Can the FAD of Z come after the FAD of Y?
   b) Can the LAD of Z come after the LAD of Y?
   c) Can the LAD of Z come after FAD of Y?
   d) Can the FAD of Z come after the LAD of Y?
4) P. 193-194.Two taxa R and S overlap in a local section.
   a) Can the LAD of R occur before the FAD of S?
   b) Can the LAD of S occur before the FAD of R?
   c) Can the FAD of R occur before the FAD of S?
   d) Can the LAD of R occur before the LAD of S?
5) What is meant by:
   a) Optimization?
   b) An objective function?
   c) What is the objective function attempting to minimize?

Group discussions: Review and present to the rest of the class the following:
1. Permutable sequences (p. 197-199)
2. Permutable matrices (p.199-201)
3. Immutable matrices (p. 204-205).

Include examples of data you might apply this method to.

Week 5:

PETERS, S. E. 2006. Macrostratigraphy of North America. Journal of Geology, 114(4):391-412.

HAQ, B. U., AND S. R. SCHUTTER. 2008. A chronology of Paleozoic sea-level changes. Science, 322(5898):64-68.

Peters 2006:

1) What are:
   a) Sequences?
   b) Sequence boundaries?
2) discuss Figure 2 among yourselves-
   a) How do the patterns in the first 3 columns relate to the chronostratigraphic chart in the fourth column?
   b) How are stratigraphic origination and extinction rates measured? Refer back to Figure 1.
3) Small groups:
   a) What is the take home message of Figure 5?
   b) What is the take home message of Figure 6?
   c) What is the take home message of Figure 8?
4) Figure 14: how does this compare with the results of Sadler (1981). Does it invalidate those results?

Haq and Schutter 2008

1) How do the results shown in Figures 1-3 compare with Figure 5 in Peters?
2) What are the time spans and controls of 1st, 2nd, 3rd order sea-level cycles?
3) Are there any terms that you do not understand?

Week 6:

HOLLAND, S. M. 2000. The quality of the fossil record: a sequence stratigraphic perspective. Paleobiology, 26(4):148-168.

ERWIN, D. H. 2006. Dates and rates: Temporal resolution in the deep time stratigraphic record. Annual Review of Earth and Planetary Sciences, 34:569-590.

Holland 2000

1) Draw the ranges of species that differ in each of the variables in Figure 2B, keeping the other 2 variables constant
2) Figures 1 and 2. How do the species depth ranges in Figure 1 compare to the model depth ranges in Figure 2? To those in Figure 2C?
3) Figure 3A:
   a) How does the proportion of sand to mud change as the we go from the bottom to the top of the parasequence?
   b) How do the sedimentary structures change?
4) Figure 3B – what is the main control over which three of the sets occur?
5) Figure 3C: how do the relative thicknesses of the three types of system track change as we go from onshore to offshore?
6) Figure 4: Small groups: examine 4B,C, and D. What is the "take home" message of each. Explain to class as whole.
7) How does Holland's model relate to the work of Peters' on macrostratigraphy? To Sadler's on gaps?

Erwin 2000

1) What is meant by a GSSP?
2) P. 571 What do you think a "taphonomically active zone" is?
3) Figure 1. What are the triangular shapes on the diagram?
4) Figure 2. 3 groups. For each of the boundaries, plot how the estimate of its age has *changed* from one time scale to the next. We will graph this on a common axis. Has the rate of change remained about the same or slowed down?

Week 7:

Palike, H., R. D. Norris, J. O. Herrle, P. A. Wilson, H. K. Coxall, C. H. Lear, N. J. Shackleton, A. K. Tripati, and B. S. Wade. 2006. The heartbeat of the Oligocene climate system. Science 314(5807):1894-1898.

Brett, C. E., G. C. Baird, A. J. Bartholomew, M. K. DeSantis, and C. A. V. Straeten. 2011. Sequence stratigraphy and a revised sea-level curve for the Middle Devonian of eastern North America. Palaeogeography Palaeoclimatology Palaeoecology 304(1-2):21-53.

Pälike et al. 2006

1. Starting at page 1894, column 3, paragraph 3 and ending p. 1895, column 1, we will take turns reading aloud and indicating where on Figure 1 the material in the text is indicated.
2. Detailed review of Figure 2. Are all the portions, labels, etc. clear?
3. What is meant by the title of the paper?
4. Does the abstract adequately summarize the key points of the paper?
5. Why do they conclude that the effect of the cycles on temperature is insufficient to explain their results?

Brett et al. 2011

1. What are the three reasons that Johnson curve of Devonian sea-level is inadequate?
2. Figure 4. What do you think the squiggly line in the middle of the two columns represents?
3. How can the duration of the Givetian be determined using:
   a. Classic biostratigraphic methods
   b. Cyclostratigraphy?
4. What assumptions underly the use of cyclostratigraphy in this case?
5. What criteria do they use to determine the amount of sea level change in the Middle Devonian?
6. What outstanding issue remains unresolved?

Week 8:

HOFFMAN, P. F., AND Z. X. LI. 2009. A palaeogeographic context for Neoproterozoic glaciation. Palaeogeography Palaeoclimatology Palaeoecology, 277(3-4):158-172.

COCKS, L. R. M., AND T. H. TORSVIK. 2002. Earth geography from 500 to 400 million years ago: a faunal and palaeomagnetic review. Journal of the Geological Society, 159(6):631-644.

1) How are the following lines of evidence used in reconstructing continental positions and how reliable are they:
   a) Group 1: Benthic organisms
   b) Group 2: Paleomagnetism
   c) Group 3: Sedimentological
2) Would fossils useful for global correlations also be useful for reconstruction?
3) How do the lines of evidence used by Hoffman and Li compare to those used by Cocks and Torsvik? See, in particular Figure 8 in Hoffman and Li.
4) Choose one of the following terranes. What is its modern geography and what are the major events/processes that describe its history during 500-400 mya?
   a) Group 1: Avalonia
   b) Group 2: Gondwana
   c) Group 3: Baltica

5) Where was the Iapetus Ocean? The Rheic Ocean? Panthalassic Ocean?
6) What are the spatial and temporal distributions of the following glaciations:
    a) Sturtian
    b) Marinoan
    c) Ediacaran
7) Why Hoffman and Li. concerned about "high obliquity"?

Week 9

Hazen, R. M., D. Papineau, W. B. Leeker, R. T. Downs, J. M. Ferry, T. J. Mccoy, D. A. Sverjensky, and H. X. Yang. 2008. Mineral evolution. American Mineralogist, 93(11-12):1693-1720.

Chapman, C. R., B. A. Cohen, and D. H. Grinspoon. 2007. What are the real constraints on the existence and magnitude of the late heavy bombardment? Icarus 189(1):233-245.

1) Hazen et al. 2008:
    a) Groups: Based on the material in the text, describe the following types of meteorites, their mineralogy, and their role in the early history of the earth:
        i) Type 3 Chondrites
        ii) Stony achondrites
        iii) Iron-nickel meteorites
    b) We will read through Table 1 and compare it to what is given in Figure 1.
    c) How does what they describe compare to biological evolution?
    d) How can we use this model to predict what minerals we will find on other planets?
2) Chapman et al 2007:
    a) We will watch a clip from a BBC show on the late heavy bombardment. Take notes on the scientific statements made in the clip.
        i) How many of these are discussed in the paper?
        ii) How strong is the scientific support for these statements?
    b) What do the authors say about the dynamical models (such as that proposed by Gomes et al 2005) for the causes of the LHB?
        i) Gomes, R., H. F. Levison, K. Tsiganis, and A. Morbidelli. 2005. Origin of the cataclysmic Late Heavy Bombardment period of the terrestrial planets. Nature 435(7041):466-469.

Week 10

Hawkesworth, C. J., B. Dhuime, A. B. Pietranik, P. A. Cawood, A. I. S. Kemp, and C. D. Storey. 2010. The generation and evolution of the continental crust. Journal of the Geological Society, 167(2):229-248.

HALVERSON, G. P., B. P. WADE, M. T. HURTGEN, AND K. M. BAROVICH. 2010. Neoproterozoic chemostratigraphy. Precambrian Research, 182(4):337-350.

1) Hawkesworth et 2010
    a) What is meant by (give text citation)

i) residue
ii) cumulate
iii) depleted mantle
iv) juvenile crust

b) What is the key feature of the preserved age structure of juvenile crust?
c) What are the "two types of ages" for continental crust and what evidence do we use for determining them?
d) What is a "hybrid model age"?
e) Why are igneous rocks usual preferred over sedimentary rocks in these studies"
f) Groups: Discuss and explain to the rest of the class:
   i) Figure 11
   ii) Figure 13
   iii) Figure 14

2) "Jigsaw" discussion.
   a) First groups: What do these elements tell us about Neoproterozoic environments:
      i) Carbon
      ii) Oxygen
      iii) Sulfur
   b) Second groups, using this data, what can we say about the environments of the:
      i) Tonian
      ii) Cryogenian
      iii) Ediacaran

Week 11

Grotzinger, J. P., D. A. Fike, and W. W. Fischer. 2011. Enigmatic origin of the largest-known carbon isotope excursion in Earth's history. Nature Geoscience, 4(5):285-292.

Erwin, D. H., M. Laflamme, S. M. Tweedt, E. A. Sperling, D. Pisani, and K. J. Peterson. 2011. The Cambrian Conundrum: Early Divergence and Later Ecological Success in the Early History of Animals. Science 334(6059):1091-1097.

1) Grotzinger et. 2011
   a) We will do this a "debate." Two groups. Include evidence for your point of view and criticisms for the other. The Sharum excursion is due to:
      i) A primary signal
      ii) Diagenesis
2) Erwin et al 2011
   a) Three groups. What are the "take home messages" of Figures 1,3,4? Include all graphed data
   b) What is meant by the "Cambrian conumdrum?"
   c) Based on this paper, what caused the "Cambrian explosion?"

Week 12

Servais, T., A. W. Owen, D. A. T. Harper, B. Kroeger, And A. Munnecke. 2010. The Great Ordovician Biodiversification Event (GOBE): The palaeoecological dimension. Palaeogeography Palaeoclimatology Palaeoecology, 294(3-4):99-119.

Shen, S. Z., J. L. Crowley, Y. Wang, S. A. Bowring, D. H. Erwin, P. M. Sadler, C. Q. Cao, D. H. Rothman, C. M. Henderson, J. Ramezani, H. Zhang, Y. N. Shen, X. D. Wang, W. Wang, L. Mu, W. Z. Li, Y. G. Tang, X. L. Liu, L. J. Liu, Y. Zeng, Y. F. Jiang, and Y. G. Jin. 2012. Calibrating the End-Permian Mass Extinction. Science 334(6061):1367-1372.

(new for next time?: Payne JL, Clapham ME (2012) End-Permian Mass Extinction in the Oceans: An Ancient Analog for the Twenty-FirstCentury? Annual Review of Earth and Planetary Sciences 40 (1):null. doi:doi:10.1146/annurev-earth-042711-105329

1) Servais et al 2010
   a) General discussion:
      i) Compare and contrast the GOBE with the Cambrian explosion.
      ii) What are the three factors of the "common cause" hypothesis of Peters (2005) and how might they be interrelated?
      iii) What are some "unique" aspects of the Ordovician; either in context of the Paleozoic or the Phanerozoic?
   b) Two groups. How might we explain the GOBE by causes:
      i) Group 1: external to the biological system
      ii) Group 2: internal to the biological system
   c) Brief discussion of: Lenton et al 2012 First plants cooled the Ordovician. Nature Geoscience 5, 86–89.
2) Shen et al. 2012.
   a) Groups: based on this paper, what evidence from the following sources constrains interpretations of the P-T extinction:
      i) Geochronology
      ii) Biodiversity
      iii) Isotope geochemistry
   b) What is the possible sequence of events suggested by this paper?

Week 14

Schulte, P., L. et al, 2010. The Chicxulub Asteroid Impact and Mass Extinction at the Cretaceous-Paleogene Boundary. Science 327(5970):1214-1218.

<u>Also see letters and responses to this paper:</u>

Archibald, J. D., et al., 2011. Cretaceous Extinctions: Multiple Causes. Science 328(5981):973.

Keller, G., et al. . 2010. Cretaceous Extinctions: Evidence Overlooked. Science 328(5981):974-975.

Courtillot, V., and F. Fluteau. 2010. Cretaceous Extinctions: The Volcanic Hypothesis. Science 328(5981):973-974.

Schulte, P., L. et al, 2010. Response - Cretaceous Extinctions. Science 328(5981):975-976.

1. What lines of evidence indicate:
   a. That was an impact at (or near) the K-Pg boundary?
   b. That the impact was correlated with the boundary?
2. What is the suggested scenario for the environmental impacts of the impact?
   a. What evidence supports this scenario?

3. What is suggested scenario for the biological impacts of the impact?
    a. What evidence supports this scenario?
4. 3 Groups: For each comment
    a. What are the principal objections made to the paper
    b. What alternative scenarios and/or evidence do they introduce?
    c. How do Schulte et al respond?

Week 15

WINGUTH, A. M. E., E. THOMAS, AND C. WINGUTH. 2012. Global decline in ocean ventilation, oxygenation, and productivity during the Paleocene-Eocene Thermal Maximum: Implications for the benthic extinction. Geology 40(3):263-266.

Hönisch, B., A. Ridgwell, D. N. Schmidt, E. Thomas, S. J. Gibbs, A. Sluijs, R. Zeebe, L. Kump, R. C. Martindale, S. E. Greene, W. Kiessling, J. Ries, J. C. Zachos, D. L. Royer, S. Barker, T. M. Marchitto, R. Moyer, C. Pelejero, P. Ziveri, G. L. Foster, and B. Williams. 2012. The Geological Record of Ocean Acidification. Science 335(6072):1058-1063.

General discussion:

1. What are the implications of these papers for our understanding of the future high CO2 world?
2. How would you explain the importance of understanding the history of the earth system to predicting future global change (include factors beyond climate)