Properties of sediment particles

Part I

Particle shape and surface texture

Grain morphology

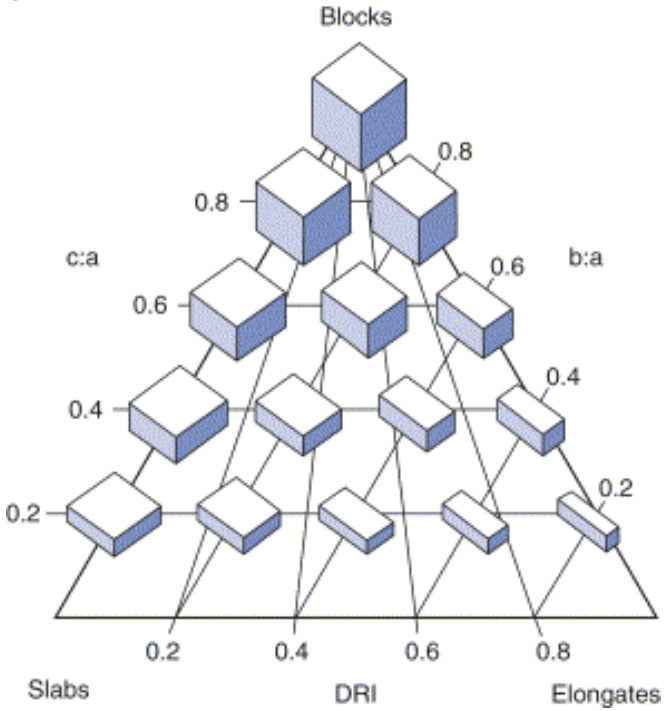
- Different processes of erosion, weathering, and transport leave distinctive morphological signatures on sedimentary particles.
  - By associating particular morphologies with particular processes, particle form analysis can be used to reconstruct erosion-transport-deposition of sediments.
  - Particle form analysis has been part of the standard toolkit of sedimentologists for many decades, and a broad range of techniques and approaches has been developed.
    - Clast form analysis refers to the study of pebble-sized or larger particles.
    - Analysis of the form of sand-sized or smaller particles is known as micromorphological analysis

Grain morphology

- Depends on
  - Original shapes of mineral grains
  - Fractures
  - Nature and intensity of sediment transport
  - Post-depositional processes
- Particle form or shape
  - Relative dimensions of the long (a-), intermediate (b-) and short (c-) axes of a clast
  - Wear patterns
    - Asymmetry
- Particle roundness
  - Sharpness of the corners and edges of a grain

Particle shape

- Particle shape describes the 3D character of a grain and may be expressed in several ways



DRI = (a-b)/(a-c)

Disk-rod index

Form parameters

L, I, S refer to the lengths of the long, intermediate, and short axes

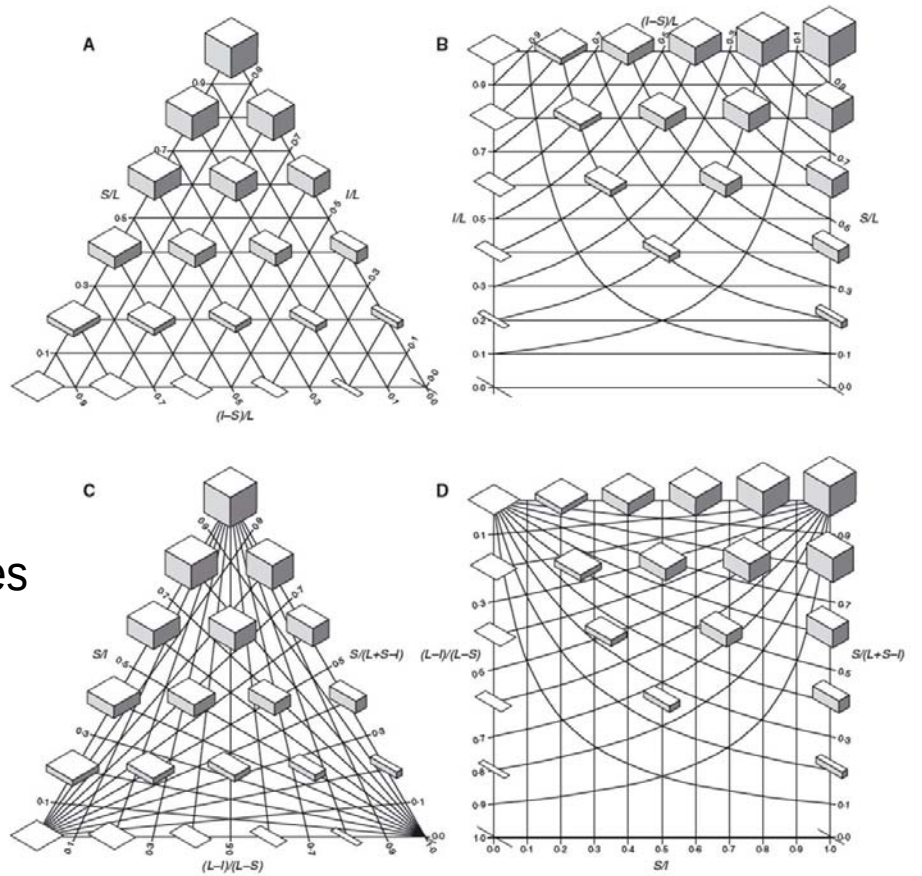


Fig. 3. The six principal form parameters identified in this paper, plotted on the Sneed and Folk diagram, with axes either parallel to the triangle sides (A), or radial from each vertex (C). For comparison, the six form parameters are also plotted on the Zingg (1935) diagram (B and D). Also plotted are 21 regular forms with *L*, *I* and *S* dimensions ranging from 10,10,10 (cube), to 10,10,0 (square), to 10,0,0 (line).

Form terminology

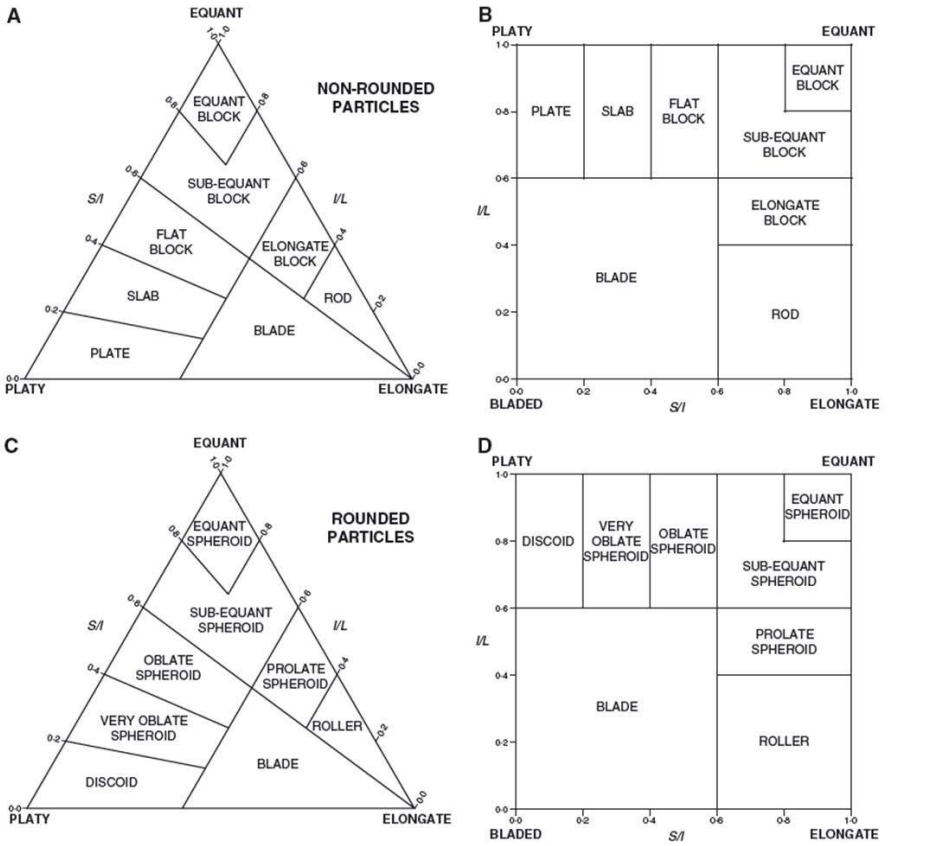
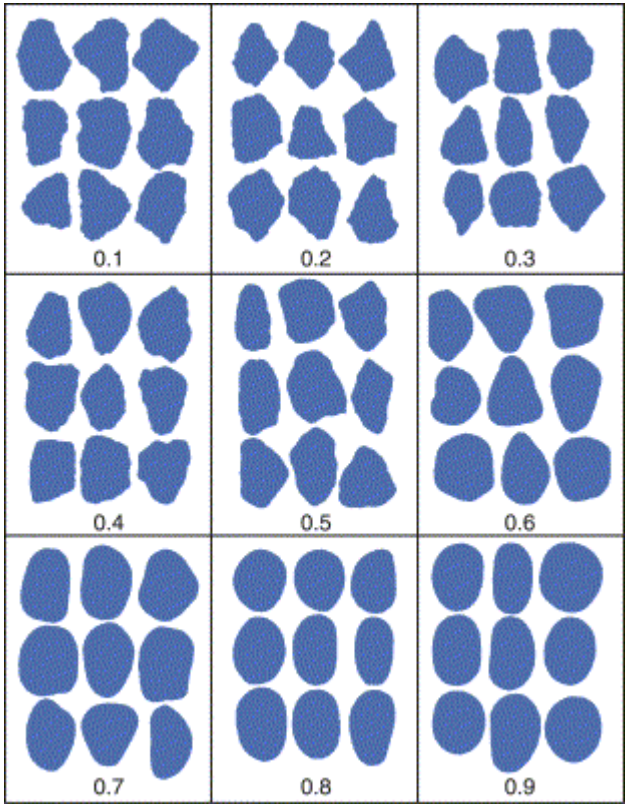
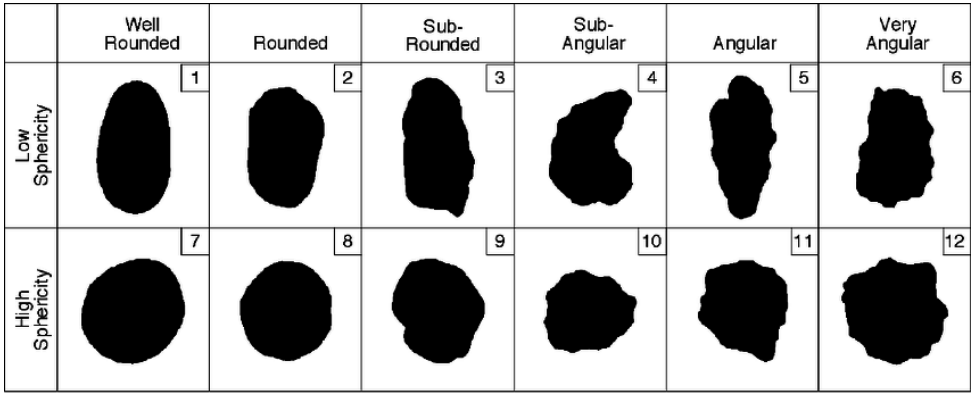


Fig. 11. Form terminology suggested in this paper, based on the degree of elongation and flatness, plotted on the Sneed and Folk and Zingg diagrams. Note that the terminology differs for non-rounded (A, B) and rounded (C, D) particles.

Particle roundness

- Here is one example of a comparison chart, in which roundness categories are represented by sets of images.
  - Objective basis for classification. However, as with all roundness classification schemes, different operators may still classify particles differently
  - Care must be taken to ensure consistency and minimize operator bias, perhaps by keeping a collection of ‘reference particles’ for comparison.
  - Digital image analysis systems are gaining traction in the area of particle shape (and size) analysis (more on that in the next lecture)





Powers (1953) Roundness classification

Grain-surface texture

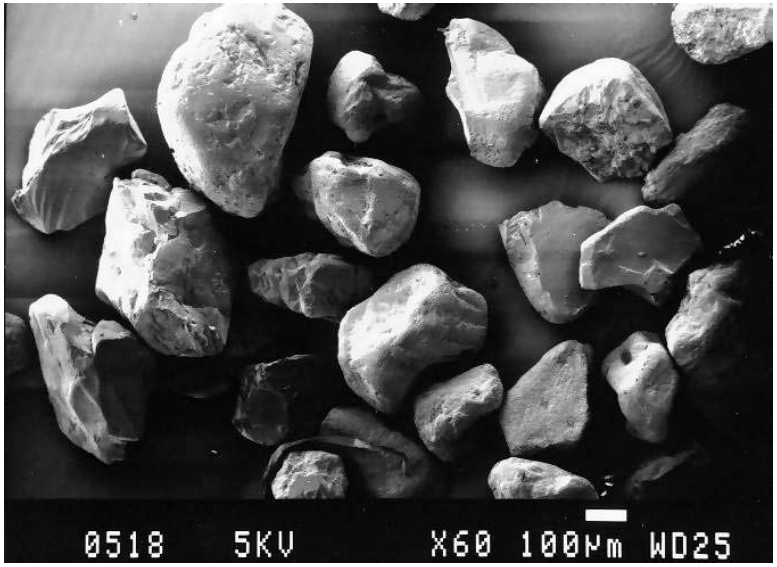
- Surface of pebbles and mineral grains
  - Polished
  - ‘Frosted’ (dull, matte texture)
  - Exhibit small-scale erosional marks
    - Pits
    - Scratches
    - Fractures
    - Ridges
  - Usually record the last cycle of sediment transport
    - However, overprinting is frequent
    - Can be use to reconstruct the ‘grain history ’

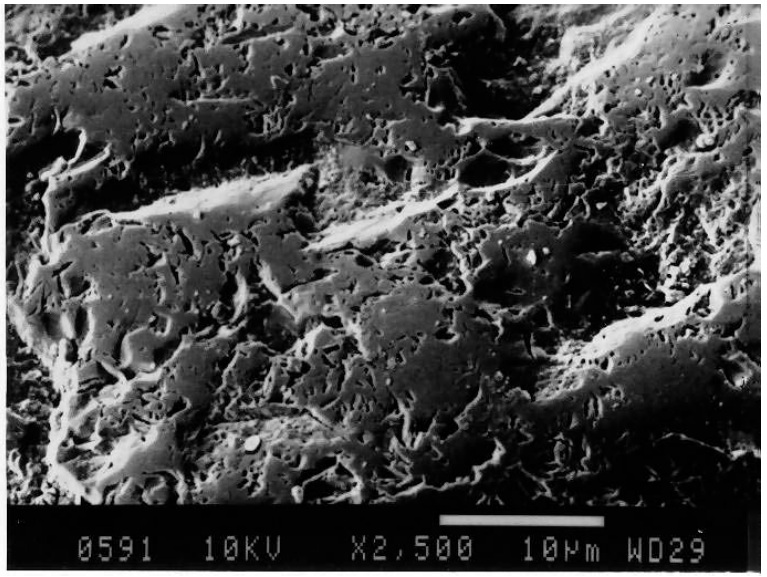
Origin

- Mechanical abrasion
- Tectonic polishing
- Chemical corrosion
- Diagenetic features
  - Eye
  - Binocular
  - Petrographic microscope
  - Scanning electron microscope (SEM)

Scanning Electron Microscopy

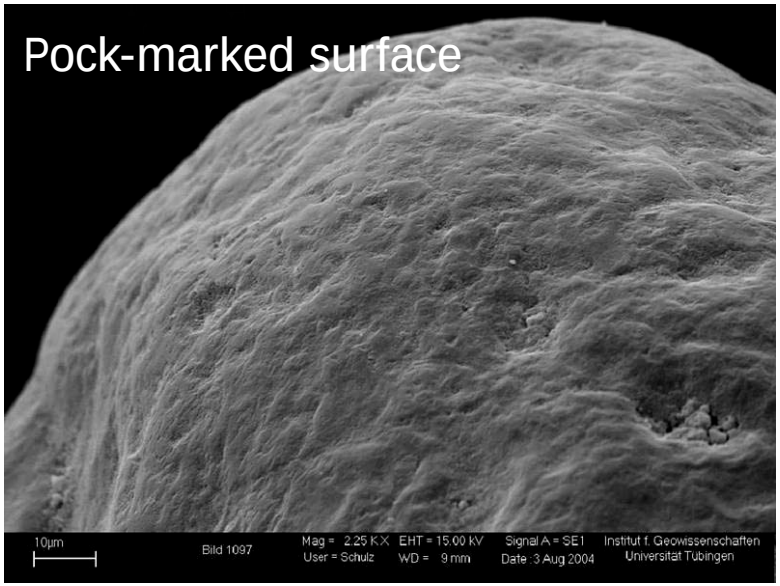
- Images on the scanning electron microscope are generated as a fine electron beam scans across a sample. This interaction results in release of energy as electrons, X-rays, and light, which are recorded by various detectors inside the microscope
- Low energy secondary electrons released from the sample by the electron beam produce images that emphasize the topography/surface texture of the sample

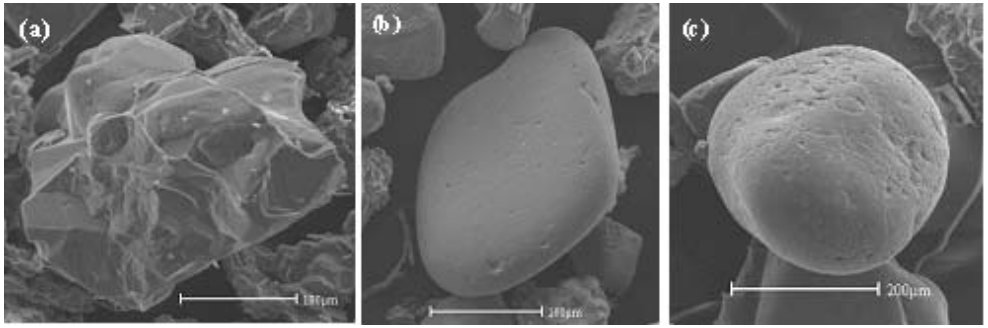




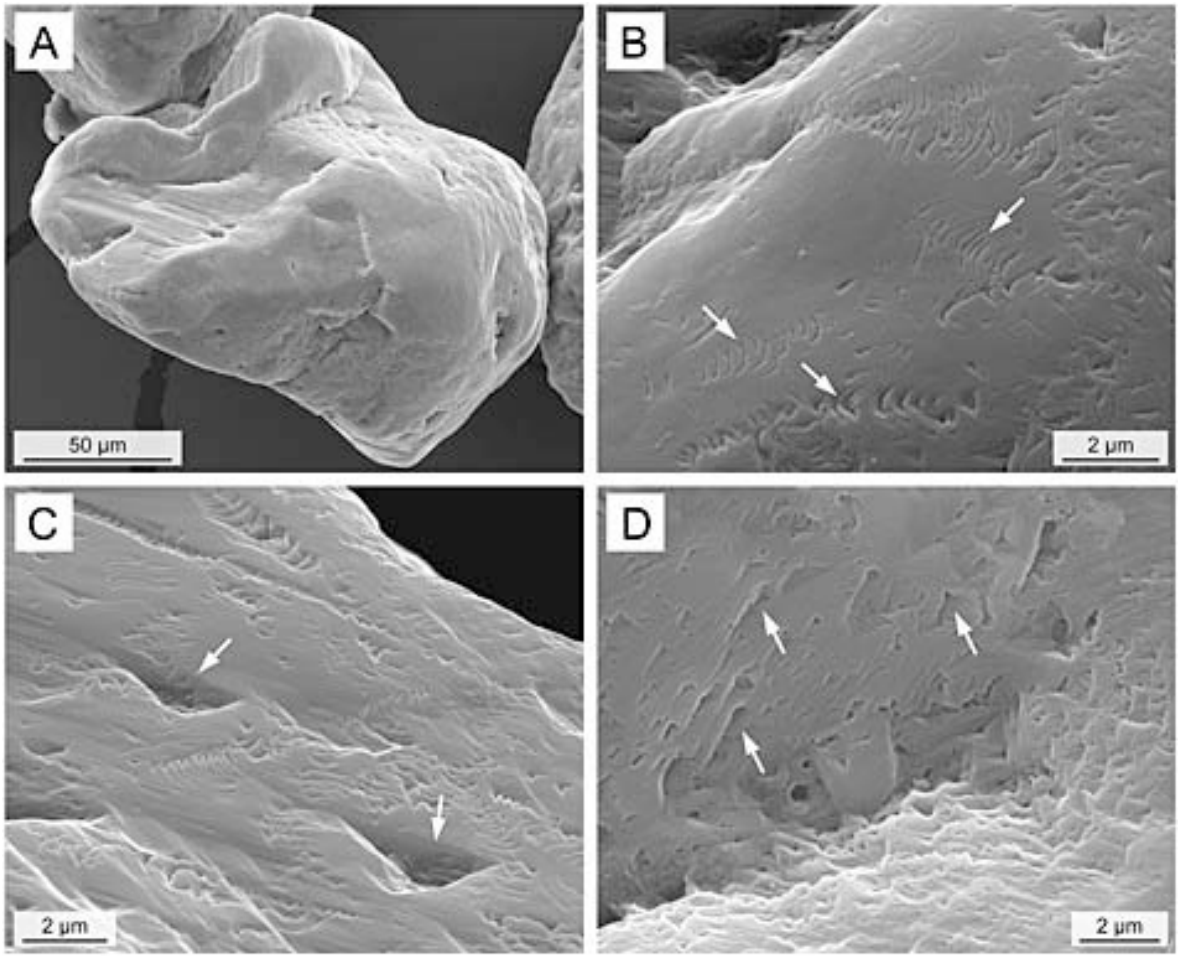
Surface textural features

- Conchoidal fractures
  - Glaciogenic
  - Littoral
- Striations
  - Glaciogenic
- Upturned plates (pock-marked surface)
  - Desert sands
- V-shaped percussion marks
  - Littoral sand
- Oriented etched Vs (chemical etching)
- Dissolution scars
- Etc.





Examples + interpretation



Scanning electron microscope (SEM) micrographs of a single quartz sand grain.

(A) Subrounded grain with smoothed edges.

(B) Glacial chatter marks (arrows) polished in a fluvial or fluvio-glacial environment.

(C) Wind transportation V-shaped percussion marks (arrows) intersecting the chatter marks.

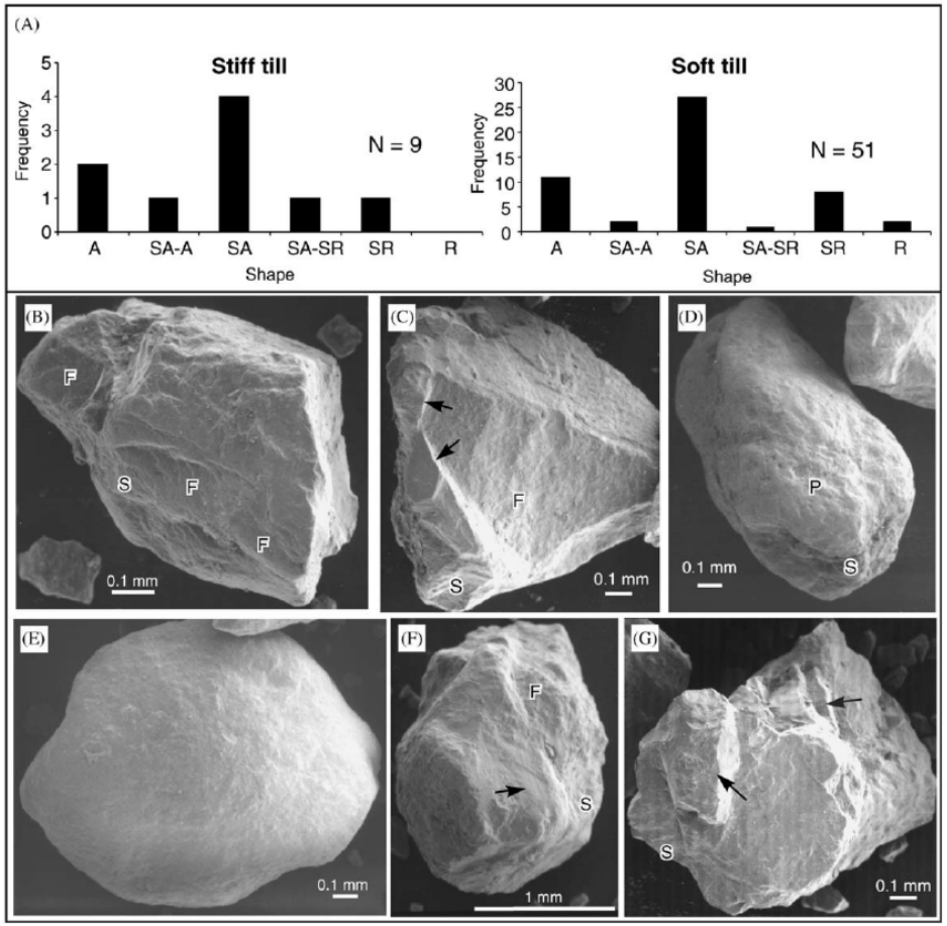
(D) Oriented etch patterns (arrows) caused by pedogenic weathering.

The relative chronology of events is interpreted as follows: (i) quartz eroded in a glacial environment, (ii) polished during fluvio-glacial reworking, (iii) transported by wind, and finally (iv) dissolved in surface during pedogenic processes.

Martignier et al. (2013) Earth Surface Processes and Landforms 38(4):331-345

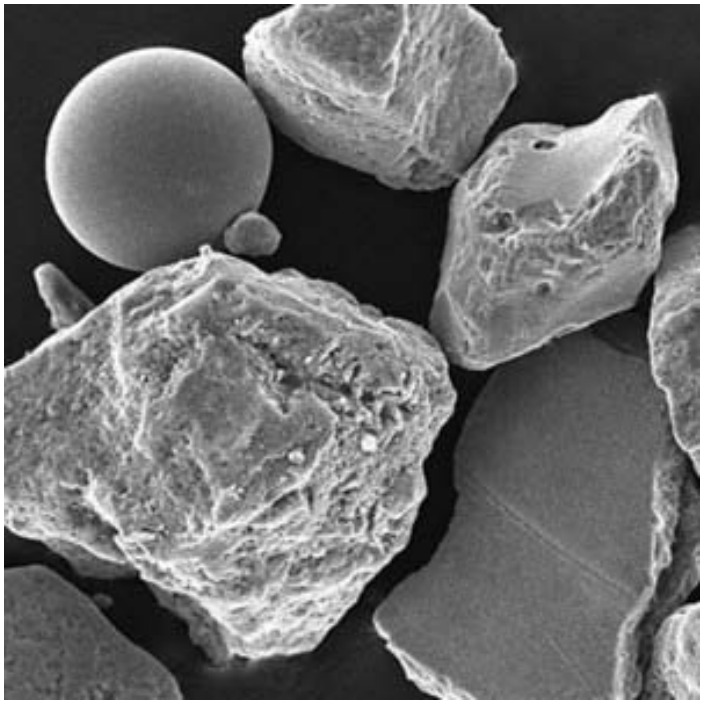
Subglacial sediment - Antarctica

smoothed conchoidal fractures (“F), steps (“S”), and sharp edges (arrowed)



Ò Cofaigh et al. (2005) Quaternary Science Reviews 24(5):709-740

What??



http://www.jsg.utexas.edu/news/2012/03/geological-fingerprint-of-war/