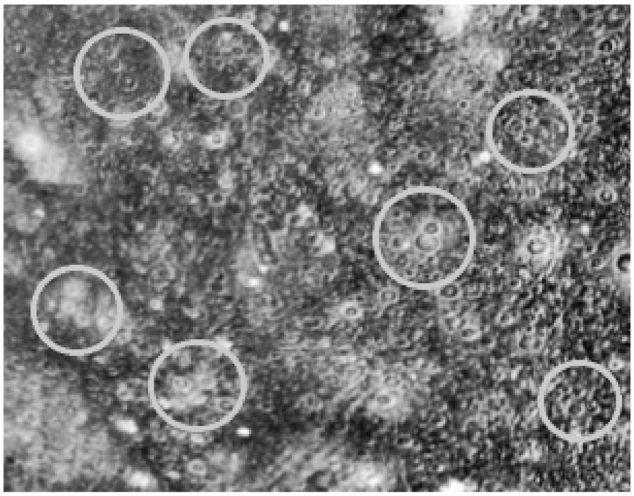
Processing 2000, Quiz 6 3/10/2000

The following image (left) is a picture of impact craters on the Jovian moon Callisto. The right image is the Jovian moon Ganymede.



Callisto

Ganymede

a) The craters in the Callisto image seem to occur in clusters (circled in image) which has lead a prominent interplanetary scientist at Xavier University (P. Costi) to propose that iron containing meteors are influenced by the magnetic field of the moon.
-Do you agree that the clustering indicates a non-random process? Explain.
-If you calculated the mixing index, M, for craters in this image what value do you expect to obtain?

b) For the Jovian Moon Ganymede (above right) Prof. Costi has determined the pairwise correlation function R(r) for craters (white spots). Prof. Costi finds that R(r) is close to a linear function given by R(r) = 1 - r/(5 km). Assuming the craters are of very low density on the surface of Ganymede,
-What is the scale of segregation, *s*, for craters on Ganymede?
-What is the usual size of a crater on Ganymede?

c) In a batch mixing process you generally know the rate of strain, the shear stress and the residence time in the mixer.
-How are these parameters used to calculate the goodness of mixing?
-Your answer should **i) define** a general measure for the goodness of mixing; **ii) explain** in words how this measure can be determined from the rate of strain, shear stress and residence time; **iii)** define any intermediate features that need to be calculated.

d) For a batch mixer sketch plots of:
-the residence time distribution function (RTDF), g(t)dt
-the cumulative residence time distribution function, G(t)
-the strain distribution function (SDF), $g(\gamma)d\gamma$ and
-the cumulative strain distribution function $G(\gamma)$.

e) **How do** the definitions of the SDF and cumulative SDF for a continuous mixer, $f(\gamma)d\gamma$ and $F(\gamma)$ differ from the definitions of $g(\gamma)d\gamma$ and $G(\gamma)$ for a batch mixer?

Answers: Processing 2000, Quiz 6 3/10/2000

a) The clustering is a natural feature of a random process as was demonstrated in class. If the craters did not form clusters you could conclude that there was something influencing their distribution.
The cratering process seems to be random in the image so the mixing index would be 1.

b) The scale of segregation for a dilute concentration of craters and a linear distribution function is L bar/2 or 2.5 km. The usual size of a crater is about 5 km. (see the analysis of the striped texture in the notes).

c) The scale of segregation is a measure of the goodness of mixing, i.e. if the scale of segregation falls below a specification value the mixture is well mixed. The scale of segregation is related to the inverse of the surface area between phases and the surface area is proportional to the accumulated strain. Integration of the rate of strain over the residence time in the mixer can yield the goodness of mixing.

d) For a batch mixer there is a single residence time, the time the mixer runs, so the residence time distribution is a single valued function. The cumulative RTD is a step function. The strain distribution function is also single valued and the cumulative SDF is a step funciton.

e) SDF for a continuous mixer, $f(\gamma)\,d\gamma$, reflects the fraction of the exiting flow rate, Q, that has been exposed to a strain between γ and $\gamma + d\gamma$. The cumulative SDF for a continuous mixer, $F(\gamma)$ reflects the fraction of the **exiting flow rate** that has received strains less than γ. For a batch mixer $g(\gamma)d\gamma$ reflects the amount of the materials being mixed that has been exposed to a strain between γ and $\gamma + d\gamma$, and $G(\gamma)$ reflects the fraction of **the material** exiting the mixer that has received strains less than γ. $g(\gamma)d\gamma$ and $G(\gamma)$ can also be calculated for a continuous mixer if the material in the mixer at a given point in time is of importance. Table 7.2 (p. 230) shows the mathematical relationships between the various distribution functions for processing operations.