NATURAL FRACTURE SYSTEMS ON PLANETARY SURFACES: GENETIC CLASSIFICATION AND PATTERN RANDOMNESS

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One method for classifying natural fracture systems is by fracture genesis. This approach involves the physics of the formation process, and it has been used most frequently in attempts to predict subsurface fractures and petroleum reservoir productivity (Stearns and Friedman, 1972; Nelson, 1979). This classification system can also be applied to larger fracture systems on any planetary surface.

This process-based system for classification of natural fractures was originally proposed by Stearns and Friedman (1972) and later modified by Nelson (1979):

Classification of Natural Fractures

1. Tectonic
2. Regional
3. Contractional
   a. Desiccation
   b. Syneresis (chemical dewatering of clays)
   c. Thermal contraction (including lava cooling)
   d. Mineral phase changes
4. Surface related
   a. Unloading
   b. Weathering (including freeze-thaw activity)

One problem in applying this classification system to planetary surfaces is that it was developed for relatively small-scale fractures that would influence porosity, particularly as observed in a core sample (Stearns and Friedman, 1972). Planetary studies also require consideration of large-scale fractures. Nevertheless, this systems offers some valuable perspective on fracture systems of any size.

Terrestrial studies of fracture patterns have generally concentrated on just 3 of the categories listed above: desiccation, lava cooling, and freeze-thaw, which is a subset of the weathering category in the system listed here. Relatively few data are available in the literature for fracture patterns generated by unloading, syneresis, and mineral phase changes. An additional consideration in applying this classification to large-scale features is that "regional" fractures are typically generated either by tectonism, which is a separate category, or by regional desiccation and lowering of the groundwater table, which should fall under the contractional/desiccation category. Thus, the classification system may require further

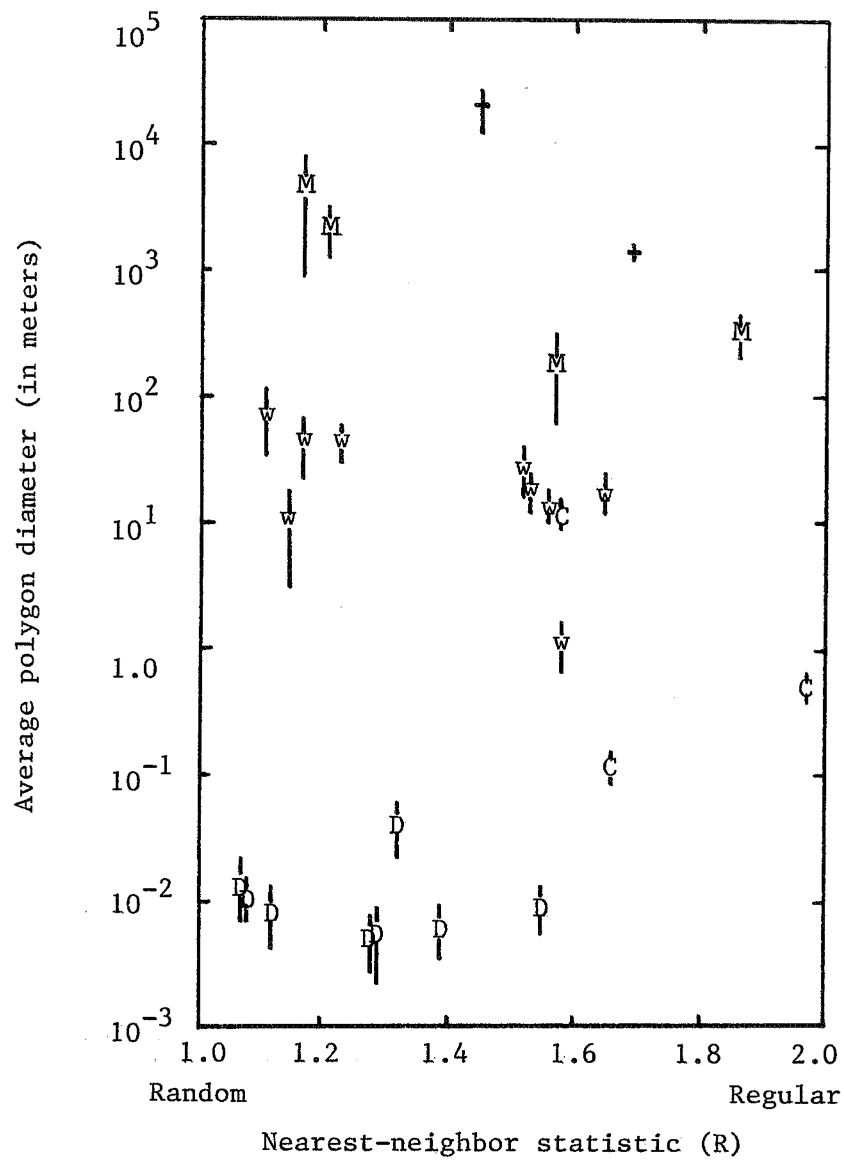

Fig. 1. The morphology of fracture patterns, as described by polygon diameter and nearest-neighbor analysis, supports the genetic classification system for natural fractures (+ = tectonic; D = desiccation; C = thermal contraction; W = weathering; M = Martian fractures - no genesis inferred). Data from Rossbacher (1985, 1986a, 1986b, 1986c).

modification to make it clearly reflect genetic processes.

Two approaches to quantifying the morphology of the fracture system are measuring polygon diameter and determining the randomness of the pattern itself. The latter can be calculated by applying nearest-neighbor analysis, which yields the R-statistic (Rossbacher, 1985, 1986b).

The R-statistic can be plotted against average polygon diameter for the various categories of natural fracture systems (Fig. 1). Although Figure 1 does not include sufficient measurements within several categories to allow definite conclusions, the data do support several tentative interpretations: 1) The genetic classification system for natural fractures does seem to describe specific relationships between polygon size and pattern randomness. 2) The fracture patterns observed on the surface of Mars do not clearly fall into any of the other categories for terrestrial features. This suggests that either the Martian fractures formed by yet another process or the physics of the fracturing processes are sufficiently different on Mars that the morphology of the Martian landforms cannot be directly compared with their terrestrial analogs. If size and pattern randomness are controlled by the mechanism of formation, as suggested by the data presented here, then it may be possible to infer fracture origin from the morphology, at least for terrestrial examples. The parameters controlling the physics of the process need to be better understood in order to apply similar interpretations to Martian fracture patterns.

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