REGIONAL LANDFORM THRESHOLDS

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One of the more significant trends in geomorphic thinking is the continuing development of the threshold concept. The importance of the concept stems from its premise that boundary conditions exist within geomorphic systems beyond which different processes will prevail or existing processes will change in magnitude or rate. Identification of the critical (threshold) conditions in terms of real parameters would allow geomorphologists to provide extremely valuable information to disciplines such as land management or environmental planning. In light of this, most studies involving thresholds have concentrated on establishing the conditions at which process change manifests itself through local erosion or deposition or by a change in the character of the process agent (rivers, glaciers, etc.). The emphasis on process thresholds seems to be prevalent regardless of whether the change is induced by internal or external factors. These studies are very important, but they require long and tedious collection of data.

The application of space technology to the understanding of process thresholds is an appealing goal of megageomorphology, but it may be extremely difficult to achieve because of spatial, magnitude and temporal problems. For example, changes in process attendant to the onset or decline of glaciation and the rise and fall of sea level are certainly large enough in magnitude to qualify as mega-thresholds. However, the time required to reach the threshold condition is probably well beyond the feasibility of continuous space monitoring. Other events such as the large dust storms viewed from space reveal processes that operate on a large scale. Clearly, these events represent the crossing of a threshold boundary of wind erosion, but whether they can be considered as a mega-threshold depends on factors such as recovery time. After the event has occurred the system may quickly revert to its original process condition of rate and magnitude. Thus, the threshold crossing may be only a minor aberration of process in a temporal sense, even though it was large in magnitude and affected a vast area.

Remote sensing technology allows us to recognize manifestations of regional thresholds, especially in the spatial characteristics of process agents. For example, a change in river channel pattern over a short distance reflects a threshold alteration in the physical controls of discharge and/or sediment. It is, therefore, a valuable indication of conditions as they exist. However, we probably will have difficulty determining whether the systemic parameters are now close to threshold conditions at which a different change will occur. This, of course, is a temporal and magnitude problem which is difficult to solve from the spatial characteristics. Certainly we can tell where threshold conditions have been exceeded. Paleochannels and exhumed regional landscapes are testimony to mega-thresholds, and to the fact that part of the surficial environment is not adjusted to present conditions. However, it is difficult to ascertain from space when the mega-threshold was passed and at what parameter limits.

Despite these problems, the threshold concept should not be abandoned in megageomorphology. Another approach to the threshold concept might be to consider whether large geomorphic features also respond to external changes such as climatic variation or tectonic activity. In other words, do we have large scale landform thresholds whereby changes in external controls require significant adjustments in the character of the features themselves? Assuming that landform properties represent an accommodation between process and form, it might follow that process thresholds are forerunners of changes in the "equilibirum" character of landforms. If this scenario is viable, it suggests that continous monitoring of landforms in regions experiencing climatic change or tectonic activity could yield important insights as to how and why landforms change. The converse may also be true. In addition, identification of the conditions that produce landform thresholds and the extent and nature of the response could also be important in disciplines concerned with the environment. Certainly the planned development of large communities in areas having landforms prone to threshold response would benefit by knowing what changes might be expected in the surface environment if external factors were altered.

It now seems certain that process thresholds can occur rapidly and often in response to relatively minor changes in controlling factors. It also seems clear that landofrms are not permanent and, therefore, must change. The question, however, is whether they change within the temporal and spatial framework of the threshold concept. Thus, the suggestion of landform thresholds producing rapid adjustments to changing external factors is pure conjecture. Nonetheless, it is conjecture that can be tested. The reality of landform thresholds producing rapid response might be ascertained in areas that are presently experiencing climatic change or tectonic activity. Perhaps an excellent starting point would be to examine large alluvial fans and pediments in the extreme southern part of California. Recent acceleration of beach erosion and sea cliff retreat in this area has been attributed to a reasonably well-documented climatic change that began in the late 1970s. The suggested climate variation toward greater storminess and higher annual rainfall is based on long-term precipitation records and tree-ring analyses, in addition to varve thicknesses measured in Santa Barbara Basin. These data indicate that significant episodes of increased rainfall occur with a periodicity of about 30-40 years and last for about ten years. It is not certain how far inland this climatic shift penetrates, but parts of the Transverse Ranges are apparently being affected. Long-term weather records should be available farther inland to determine the areal extent of the climate change and its regional magnitude.

Assuming that a climatic variation has begun, what questions should we be asking about geomorphic features, and what information should we seek that might be provided by remote sensing technology? A few examples are offered using the climate change - fan adjustment as a model.

1) What geomorphic properties of large fans are best indicators of climatic change? In general it seems likely that morphometric parameters should be most fruitful in documenting any landform adjustment. Precisely which parameters should be employed will probably depend on the resolution of the sensing system. For example, the well known relationship between drainage basin area and fan area could easily be measured because the entire fluvial system can be viewed simultaneously. Depending on sensing resolution, it may also be possible to detect changes in drainage density in the source areas and the fan areas, and the ratio of the two. A change in fan shape might be determined by the relationship between perimeter length and fan area.

2) To what degree does human activity accelerate or depress the expected landform adjustments? Fans are commonly the locale of community development which may prevent adjustment. In contrast, various activities in the source areas may accelerate fan responses. Comparison of fans in sparsely inhabited areas, such as Baja, California, to those in highly developed regions could indicate the effect of human activity.

3) How long does it take for landforms to respond to climatic change? It may be that fans do not respond to climate variations having the cyclicity mentioned above; however, even that information would be significant.

4) What magnitude of climate change is needed to produce tangible modifications in fan character? Perhaps large fans are affected only by climatic variation having the magnitude of the glacial-interglacial cycle. If responses do occur, and it can be shown that the climate change is regional in extent, fans in different parts of the southwest U.S. may adjust in different ways and with a hierarchy of intensities. Some relationship might exist between the magnitude of climate change and the rate and degree of fan modification.

5) Are intrinsic fan thresholds real or do they represent responses to minor changes in external controls? Certain fan phenomena such as alternating fanhead trenching and filling are conceivably part of internal fan mechanics involving changes in channel slope at the fan apex. These reactions are logically controlled by an intrinsic threshold. It is also possible, however, that they represent adjustments to minor, periodic shifts in external controls. Simultaneous responses of the same type occurring on fans over a wide regional extent may indicate adjustment to external rather than internal controls.

6) It there a size of fan threshold? It may be possible that the response or non-response of a fan to minor climatic variation is dependent on the fan size. Small fans may respond, but larger fans may require greater

magnitude of climate change or a longer time to reveal a tangible change.

The questions posed above are meant to be examples and are certainly not the only ones possible. It does seem, however, that modern sensing technology allows us to raise and possibly answer a variety of questions that would require enormous effort using more traditional geomorphic approaches.