THE ROLE OF MAPS IN HAZARD MANAGEMENT

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ABSTRACT

Any management of human response to natural and technological hazards entails the movement of information, people, goods and services over space. Maps contribute the essential models of cognitive patterns required by planners and emergency managers. This includes graphic depictions of the locations of hazards, their degrees of risk, methods for hazard control and response, and hazard mitigation strategies. A variety of map types arise from the four major objectives of hazard management: hazard identification, risk assessment and social evaluation, emergency management, and risk communication. Full funding for these cartographic support materials is required before, during and after a natural or technological disaster.

Hazard management mapping develops within the interdisciplinary context of hazard research and cartography. These diverse endeavors within geography each has theoretical paradigms which must be accommodated in the design of hazards management maps. Cartographic acumen must be consolidated with the findings of hazard research to facilitate the three basic ongoing processes of: 1) map design and production, 2) map use for planning, crisis control, risk communication, and pre-post mitigation attempts, and 3) map influence affecting risk perception and perhaps even political decisions. The resulting taxonomy of maps is suitable for application in solving both natural and technological hazard problems.

1 INTRODUCTION

Down through the dim mists of human evolution, humans have continually adjusted to physical threats to themselves and to what they value that are termed hazards. Management of these threats, not just by individuals, but through a coordinated scientific process, is a relatively young activity. Today, attempts are made to scientifically manage the effects on humans of both natural and technological hazards, and maps play an integral role in the visualization, conceptualization and decision making processes involved.

1.1 The Hazard Realm

Figure 1 depicts and characterizes the elements of the two major hazard domains: natural and technological. Disease threats are not included; they are managed by the medical community. Natural hazards are comprised of extreme geophysical events which may be *intensive* (short, rapid, enormous energy per unit area) in action, such as avalanches, blizzards, earthquakes, flash floods, frost, hail, lightning, tornados, tsunamis, tornados and volcanos. Those of a *pervasive* character (long, slow, small energy over a large area) are coastal erosion, desertification, drought, floods and soil erosion. Threats with combined intensive and pervasive stages constitute *complex* natural hazards such as riverine floods and hurricanes (cyclones). [1] For a taxonomy of technological hazards, research at Clark University's Center for Technology, Environment and Development in Worcester, MA [2] suggests that three primary levels of threat exist: *hazards, extreme hazards* and *multiple extreme hazards*. Within these three classes, seven categories are recognizable when technological hazards are compared on the basis of their generic characteristics. These encompass a multitude of ordinary hazards including those whose greatest threat often comes from a *release of energy* such as household appliances, bicycles, skateboards, and power mowers, and those whose threat results from *release of a material* such as saccharin and aspirin. Five types of extreme hazards include *intentional biocides* (chainsaws, antibiotics, vaccines), *persistent teratogens* (uranium mining, rubber manufacture), *rare catastrophes* (commercial aviation crashes, LNG explosions), *common killers* (auto crashes, black lung disease from coal mining), and *diffuse global threats* (carbon dioxide from burning fossil fuels, ozone depletion from chlorofluorocarbon use and SST flights). Multiple extreme hazards produce *extreme consequences in more than one factor of their description* and cover hazards such as dam failures, pesticides, recombinant DNA, radiation from nuclear war, and use of nerve gas in war. Mapping serves in a crucial capacity in the human handling of the effects of each of these natural and technological hazards.

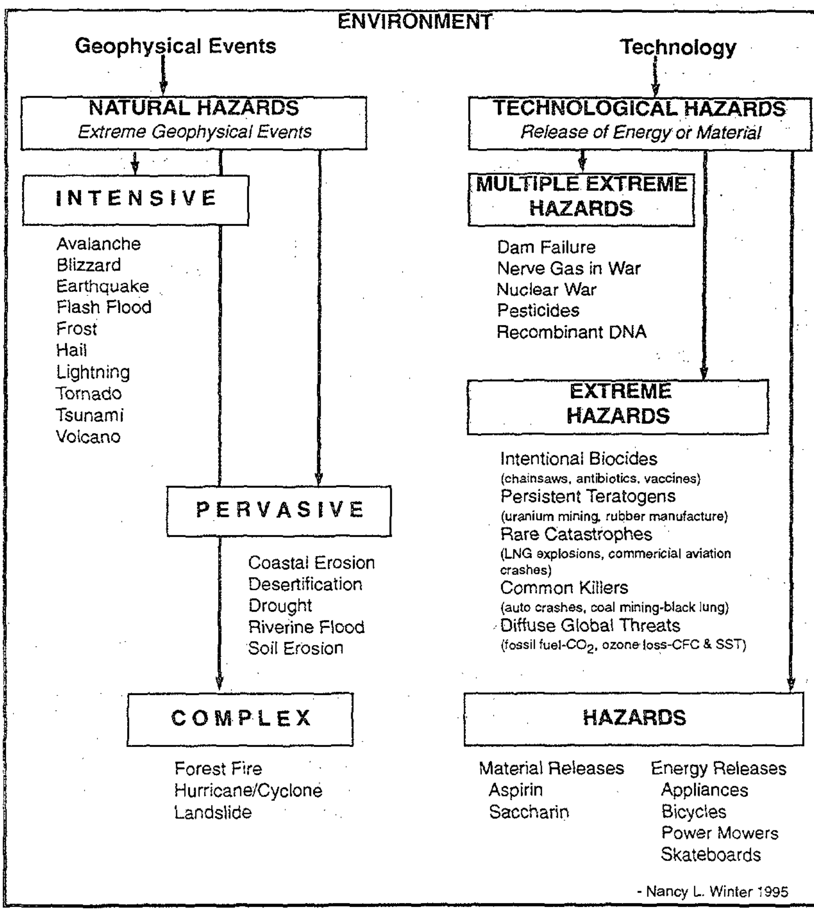

Figure 1: Taxonomies of Natural and Technological Hazards
[1, pp. 514-517, 2, p. 47]

the Phanerozoic, the last 600 million years. The map on the right depicts two notable cases. The dotted and solid lines with movement arrows show where a series of meteors in 1913 circled Earth and were observed shooting from Canada to Bermuda. The waterdrop-shaped halo on the right map unites the many craters made approximately 360 million years ago, the late Devonian period. All the paths on this righthand map go through Phanerozoic cratering nodes. Without such a cartographic rendering of the available data on comets and meteorites, there would be far less support for this new, bold theoretical leap. *Hazard maps* from research on this theory may in the future serve the most imaginative hazard managers who have brainstormed the idea that human space vehicles might intercept large comets or asteroids to deflect them from striking Earth.

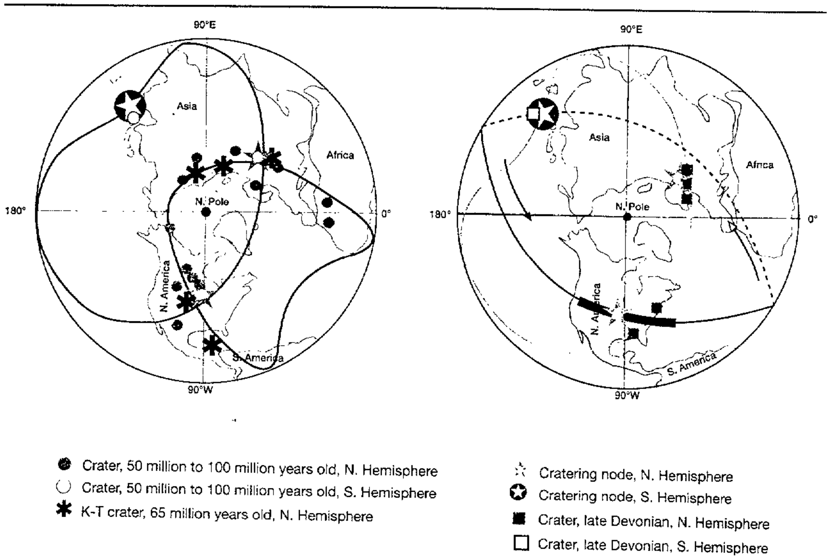

Figure 3: Hazard Maps of Cratering Nodes showing Patterns of Bolide Craters on North Polar Projections
[7, p. 59] Reprinted with permission from *SCIENCE NEWS*, the weekly newsmagazine of science, copyright 1995 by Science Service, Inc.

Screening methods also produce hazard maps that help detect hazards by their spatial distribution. Classification of the hazard potential of products, processes, phenomena, or persons is achieved through a standardized procedure of screening. Through this sort of "fishing expedition" mutagenic hazards in the environment were reported in 1975 [8]. **Monitoring** of the recurrence of hazardous events or their consequences creates the need for large numbers of hazard maps that compare time series revealing variations of some vital indicator, cumulative effects of a hazardous condition or failure of a protective apparatus. For **diagnosis**, analysis of the locations of "symptoms", an odd set of events or consequences, spawns hazard maps. Modern hazards are rarely purely natural or technological. They evolve quickly into complex socioenvironmental problems whose solutions demand use of all these hazard identification methods. For example, current investigation of ozone depletion dictates the use of hazard maps arising from research, screening, monitoring and diagnosis.

3.2 Risk Maps

Too often the terms hazard and risk are interchanged. Some of the ambiguity in use of the titles "risk" and "hazard" for given maps arises from the process of map communication. An individual may look at a hazard map and make personal mental judgments about how risky a hazardous situation appears to be. Technically, however, *risk maps* are more sophisticated products than hazard maps and reflect the results of *risk estimation*. They should involve some sort of **numerical calculation to determine the probability of occurrence and degree of risk** or at least some gross ranking of risk from low to high. This often involves extrapolation of data by augmenting the underlying database with information from the past. Uncertainty is inherent in the process of risk estimation, therefore accurately designed risk maps characteristically express quantities given in their legends in ranges rather than single numbers. Most complicated and rare of all are risk maps that aggregate the risk estimates from more than one hazard. Such risk maps must be used in a sensitive way in communicating risk to the public. A complicated set of issues are involved when maps are employed to inform the public about risks. Perceptions of risk already held by people, what levels of map reading abilities are represented in the populace, and how much trust the public has in the map makers are just a few of the issues. The key is to promote understanding without striking fear. Because of potential limits to land use and negative publicity about a given community, businesses and real estate interests discourage risk mapping, especially of aggregate risks.

3.4 Categories of Emergency Maps: Planning, Crisis and Response

Resource allocation and evaluation processes for handling hazards include the physical control and regulation of technological threats and budget decisions about the way funding will become available for pre-disaster planning and mitigation and post-disaster relief and mitigation and for monitoring these management efforts. Preparedness for emergencies requires emergency mapping for planning, crisis control and disaster response purposes. In the United States, jurisdiction over disastrous events lies with local authorities, the town or county, which should be ready to provide **planning, crisis and response maps.**

Mapping before an emergency event generates the first major type of emergency maps, *planning maps*. Whatever financial resources are made available, *planning maps* encompass the largest category of emergency maps. For broad, strategic preparedness planning in a community, including decisions as to what risks to prepare for, existing *hazard and risk maps* from town or county departments, from academia and from federal government agencies, along with local *fire and police department maps* are essential. Within the local scene in the United States, government and businesses fund much of the design and production of planning maps which are created within their ordinary operations. For example, during a disaster, ordinary *utility maps* become extremely valuable. For more detailed, comprehensive planning, special maps need to be designed and produced before a disastrous event. Planning for evacuation furnishes *evacuation route maps*, *shelter maps*, and *sensitive population maps*. Design and production of emergency maps showing the location of all *medical facilities* and all available *cold storage facilities* (for potential use as morgues) is also a planning priority. Planning should include making arrangements for certain types of maps or raw data to be made available in a disaster including postal address records, electric utility address lists, etc. which can aid in certain kinds of post-event crisis or response mapping.

The second major type of emergency mapping occurs during the peak time of a hazardous event. *Crisis maps* are made on-the-spot during the height of danger, often with crude materials. They are drawn to find ways to control the physical agent causing the disaster. By U.S. law, for disaster funds to be sent to any state by the president declaring that state a disaster area, an estimate of the amount theoretically enlarge the [illegible]er and quality of map percipients, but if the GIS map makers, do not have sufficient cartogra[illegible]ucation they may accept poor maps.

[illegible] by [illegible]

The final cartographic [illegible] in hazard management mapping is what influence the maps have on the viewer's risk perceptio[illegible] on decisions and choices made by decision makers. Research findings about the effects of ma[illegible] risk perception is so sparse as to be almost non-existent. Caution about the influence of maps [illegible]ion makers is sounded by Buttenfield and Beard [12]: "Maps are a major tool for decision makin[illegible]rly designed maps may convey false ideas about the facts represented by the data, and bias the de[illegible] making process." Basic research on decision making is scant, and Craig *et al.* [13] claim, "we d[illegible] know enough about how decision makers operate, especially how they utilize information." Fur[illegible]more, the effects of map use on decision making has had little study [14]. Such investigation covers [illegible]omplex research goals which should be moved to the top of the research agenda of cartographers to enhance our understanding of the role of maps in hazard management in terms of risk perception and decision making.

4.2 Dangers in Scientific Visualization

Scientists and graphics professionals are concerned about the perils that lie in the generation of inappropriate computer graphics to report scientific data [15]. Powerful and sophisticated software for scientific visualization now permits scientists to explore numerical data to identify areas of interest and then to present their findings in stunning graphics, many of them in essence cartographic. A wide range of problems can ensue. Sometimes these graphics don't reveal the data, but hide it. Or, the data is very thin, but the chosen visual representation does not make this apparent. Forgetting their scientific purpose, presenters sometimes treat data in a nonchalant way or go too far in seeking appeal to portray a compelling argument or to pick a special viewpoint that helps hide a negative feature. Other problems include failure to inform viewers that a special angle of view was purposely chosen or the data was smoothed or managed to produce the visual. Flashy cartographic-type graphics are not necessarily used to intentionally deceive the viewer but to create an attractive picture. To address these problems, Joel Welling of the Pittsburgh, Pennsylvania Supercomputing Center proposed a set of guidelines for doing scientific visualization. Their scope includes the very basic rules of providing time scales and units of measurement to the intricate idea of making sure that completely original visualizations not give the impression that they are based on physical law. The primary message in his guidelines is that full disclosure of techniques or manipulations of data be offered--"a kind of truth-in-packaging for scientific visualizations." [15] For cartographers, it means that whatever methods are used to reveal insights, such as exaggerating scale or color, they should be documented for the map user.

5 CONCLUSIONS

The three major cartographic processes infused into society's management of hazards - map design and production, map use, and map influence - deserve more research attention. Fundamental cartographic research into these processes will enhance these five major roles for maps in hazard management:

1) alerting humans and human society to the existence of hazards;
2) revealing the spatial dimensions of what and where the hazards are;
3) depicting their probability of occurrence and degree of harm;
4) supporting emergency handling of human response when natural or technological hazards produce disaster;
5) monitoring human efforts to manage hazards; and
6) facilitating risk communication with the general public.

Today's information technology revolution is expected to strengthen map design and production, but the promise of technology is dimmed somewhat by the hurdles of implementation that lie ahead. Still, in many cases hazard management would founder without the aid of maps for cartographic visualization.

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