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Possible Roles for the U.S. Geological Survey in Impact Hazard Analysis and Response

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PAPER

1. Introduction

Asteroid and cometary impacts large enough to warrant public concern (Torino Scale 5 or higher) are low-probability but high-consequence natural hazards. The United States Geological Survey (USGS) has Federal statutory responsibility to provide notifications and warmings for geologic hazards, including earthquakes, volcanic eruptions, and landslides in the United States. Furthermore, USGS data directly support the National Oceanographic and Atmospheric Administration and US Air Force in their natural hazards warning responsibilities related to tsunamis, flooding, and space weather. The USGS is regularly called to assist other nations in their monitoring and response to natural disasters.

The USGS' internal organization provides emphasis to natural hazards comensurate its responsibilities. Hazards are one of the 7 mission areas that encompass all USGS activities. Within the Hazards mission area, there are 11 programs/activities and most of them are relevant to evaluating and responding to meteorite impacts. The objective of this paper is to briefly highlight these capabilities the USGS could bring to planetary defense.

2. Discussion

In addition to the specific capabilities that we discuss below, there is a more generic skill that is worth noting. Because of the breadth of natural hazards the USGS deals with, and the global nature of many of its endeavors, the USGS as a whole has considerable experience dealing with low-probability but high-consequence natural events. Just as the monitoring of the nearly continuously active Kilauea Volcano in Hawaii maintains a cadre of USGS volcanologists experienced with active eruptions, the USGS has a workforce and organizational culture that is experienced with dealing with the uncertainties and consequences of rare disasters. Even if the details of meteorite impacts differ from the specific natural hazards the USGS regularly deals with, it has valuable – and hard earned – experience to share. In particular, the USGS has spent decades developing, and vigorously defending, its reputation for providing unbiased and accurate scientific information – in a form useful to decision-makers within and outside of government. This reputation is especially important in the emotionally-charged environent of a natural disaster that may or may not happen. However, in the remainder of this paper we would like to make the point that there is also a far more direct tie between USGS Hazards science and impact processes.

<u>2.1 USGS Emergency Management</u>: The USGS maintains a Hazard Response Executive Committee, which provides executive direction, oversight, and support to USGS managers in responding to major hazard events. During incidents of national significance, the USGS provides has a well-defined role in the National Response Framework. The USGS plays a leadership role in providing imagery and geographical information system (GIS) related information to emergency operations centers (EOCs). The USGS is already partnered with >2,000 state, local and tribal governments, the academic community, federal allies, non-governmental organizations, and the private sector. The USGS is also the planner for the Department of Interior when it comes to economic stabilization, community recovery, and mitigation after a disaster.

<u>2.2 Global Seismographic Network</u>: The USGS maintains a permanent digital network of state-of-the-art seismological and geophysical sensors connected by a telecommunications network. The GSN provides near-uniform, worldwide monitoring of the Earth, with over 150 modern seismic stations distributed globally. The GSN was formed in partnership among the USGS, the National Science Foundation (NSF) and the Incorporated Research Institutions for Seismology (IRIS). This network would provide the fastest and most direct measure of

the energy of a meteorite impact on the surface of the Earth. For impacts in remote areas, especially at sea, it may also provide the first estimate of the location of the impact.

2.3 Earthquate Hazards Program: Within this four-agency partnership, the USGS provides research and information products for earthquake loss reduction, including hazard and risk assessments, comprehensive real-time earthquake monitoring, and public outreach. One of the most significant effects of a significant meteorite impact is the resulting ground shaking. The propagation of this energy through the Earth is not fundamentally different from Earthquakes. As such, the maps and models developed to predict seismic shaking in response to a fault rupture are applicable to an impact. As many earthquakes have shown the distribution of damage is highly sensitive to the nature of the subtrate on which buildings stand. By relating the expected consequences to earthquakes, a significant portion of the public will be able to more rationally plan for an impact.

2.4 Coastal and Marine Geology: Under this program, the USGS conducts research on marine geohazards including earthquakes, tsunami, and submarine landslides and on coastal change hazards from erosion, hurricanes and other extreme storms, and sea-level rise. Given the probability that a meteorite would hit an ocean, the resulting tsunami is of major concern. The USGS has numerical models to produce detailed simulations of the run-up of a tsunami. Equally important, the USGS has done extensive research on paleo-tsunamis that is essential for making realistic models.

2.5 Landslide Hazards: The USGS conducts landslide hazard assessments, pursues landslide investigations and forecasts, provides technical assistance to respond to landslide emergencies, and engages in outreach activities. A sometimes overlooked consequence of ground shaking is landslides. Especially if the impact affects an area not regularly exposed to earthquakes, landslides may cause unexpected losses outside the area directly affected by the impact.

2.6 Floods: The bulk of the USGS activities related to floods and droughts are carried out through programs within the Water Mission Area, but the Hazards program does include experts in catastrophic dam-break floods. Depending on the location of the impact, natural and man-made lakes could catastrophically empty, causing extensive losses.

2.7 Volcano Hazards: The USGS monitors active and potentially active volcanoes, assesses their hazards, responds to volcanic crises, and conducts research on how volcanoes work. The models for the dispersal of volcanic ash can be applied to predict the dispersal of dust after an impact. There may be significant, albeit temporary, concerns for aviation safety related to this dust.

2.8 Wildfire Hazards: The USGS carries out a wide range of wildfire-related science activities that span multiple USGS mission areas, including landscape ecology studies, geospatial support for fire response, burned area hydrology, and post-fire debris flow warnings. For larger impacts, the radiative heating from debris could generate extensive wildfires. Also, the response of the denuded landscape in the immediate vicinity of the impact should be similar to post-fire changes.

2.9 Science Applications for Risk Reductions (SAFRR): The SAFRR project focuses on building partnerships to improve the use of natural hazards information from the USGS, to identify needs and gaps, and to develop new products that increase the use of USGS science by emergency managers and community decisionmakers in order to promote greater resilience to natural hazards. SAFRR evolved from the Multi-Hazards Demonstration Project in Southern California, which has developed interdisciplinary, science-based products that deliver information that starts with the hazard and carries through to impacts on the community. This is the program that has coordinated and implemented full-scale, multi-hazards, multi-agency disaster scenarios like “ShakeOut” and “ARkStorm.” ShakeOut has 13.2 million registered participants, including over 8.7 million who plan to participate in a drill on October 18, 2012. These scenarios have been used by emergency managers throughout California and incorporated into federal, state, local, tribal and business catastrophic preparedness plans. The use of this methodology is expanding and now includes international participation. The creation of these disaster scenarios led to new understanding of the vulnerabilities associates with disasters and the fragility of interdependencies that can be address through mitigation and preparedness. In addition, the scenarios have produced models that have applications beyond emergency preparedness (e.g., CoSMoS and California Landslide Susceptibility Map). These scenarios highlight the value in clearly delineating the information and decision making chain for an event like an impact.

2.10 Astrogeology Science Center: This is the portion of the USGS that serves the nation, the international science community, and the general public in the pursuit of new knowledge about our Solar System. The program has participated in analyzing data from numerous missions to planetary bodies, assisting in finding potential landing sites for exploration vehicles, mapping our neighboring planets, moons, and asteroids, and conducting research to better understand the geologic processes operating on these bodies. The mapping capabilities in Astrogeology are essential for any systematic investigation of the surface and interior of a potentially hazardous asteroid or comet. For impacts of the Earth, Astrogeology staff have numerical models for the thermal effects of impact ejecta and curate key samples from Barringer Crater and other impact sites.

3. Conclusions

The United States Geological Survey is not currently involved in any meaningful way in planetary defense. However, it has many capabilities and skills that would be of use, especially in assessing the consequences of a meteortite impact on the Earth and planning a response.

4. Vitae

Laszlo Kestay (formerly Keszthelyi) is the director of the USGS Astrogeology Science Center, which has a staff of over 70 scientists, cartographers, information technology specialists, and support personell. He is a research volcanologist who has studied long lava flows on the Earth, Mars, and Jupiter's moon, Io. He has been involved in the Galileo, Mars Exploration Rover, Mars Reconnaissance Orbiter, and Lunar Reconnaissaince Orbiter misisons.

Dale A. Cox is USGS Pacific Region Hazards Coordinator and Region IX Chair of the Department of Interior, Regional Emergency Coordination Council. Cox was co-creator and Project Manager of the USGS Multi-Hazards Demonstration Project, the ShakeOut Earthquake Scenario, and on the Steering Committee of the "The Great ShakeOut", an emergency response exercise occurring annually with nearly 19 million people participating internationally. Cox also led "ARkStorm," a disaster scenario to examine the impacts and improve resilience to catastrophic west coast storms. He also coordinated the 2010 Tsunami Summit and the 2011 USGS Arizona post-wildfire response.