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(1) WORKSHOP ON "COMET/ASTEROID IMPACTS AND HUMAN SOCIETY"

Reported by W. Bruce Masse

A workshop "Comet/Asteroid Impacts and Human Society" was held at Tenerife in the Canary Islands between November 29 and December 1, 2004. The workshop was initially conceived by members of the International Astronomical Union (IAU), and was ultimately sponsored by the International Council for Science (ICSU) with partial funding support from UNESCO. Peter Bobrowsky (International Union of Geological Sciences) and Hans Rickman (IAU) organized the workshop. The Museo de La Ciencia y El Cosmos graciously hosted the workshop. The aim of the workshop was to bring together a diverse set of individuals and disciplines to explore aspects of the cosmic impact hazard, with a goal of producing a state-of-the-art synthesis regarding the likelihood and implications of a comet/asteroid impact and its effect on human society. The participants included astronomers and astrophysicists; geophysicists and others in the earth and atmospheric sciences; mathematicians; archaeologists; economists; sociologists; psychologists; risk specialists; and journalists.

A series of keynote addresses were presented the first day of the workshop. These included an opening address by Clark Chapman as to why NEOs (Near Earth Objects) are a pressing concern; Bill Bottke on the known population of potential impactors; Giovanni Valsecchi on evaluating the risks of impacts and the efficiency of risk reduction; Richard Grieve on the geological record of impacts; Bruce Masse on the archaeological and anthropological record of impacts; Giuseppe Longo on the 1908 Tunguska event; Ted Bryant on the potential for oceanic impactors to create mega-tsunamis; Jay Melosh on indirect effects of large terrestrial impacts; John Birks on the chemical and climatic consequences of impacts; Mohammed Dore on the economic aspects of impact for society; Paul Slovic on the psychological aspects of impact for society; Kenneth Hewitt on the sociological aspects of impact for society; Michel Hermelin on communicating impact risks to the public; and Stefan Michalowski on the political aspects of impact for society. A paper on disaster management and emergency response by Lee Clarke was prepared but could not be delivered in person by Clarke. Other workshop participants in addition to the organizers included Johannes Andersen, Mike Baillie, Andrea Carusi, Harry Foster, Dan Gardner, Viacheslav Gusiakov, Ted Hartwell, Jesús Hernández, Leo Hickey, Mark Kidger, E.M. Kolesnikov, Paul Kovacs, Wolfgang Kundt, Anny-Chantal Levasseur-Regourd, Michael McCracken, Bill McGuire, Brian Marsden, Jesus Martinez-Frias, Sharad Master, Oliver Morton, David Morrison, Roy Sidle, Siim Veski, and Ben Wisner. Wing-Huen Ip prepared a paper but could not attend.

The second day of the workshop was devoted to breakout sessions in which participants were divided into three groups. During this period, non-keynote participants presented 10-minute talks on their special interests. Each group then spent between 60 to 90 minutes examining each of the four breakout session themes. These themes included: (1) Is the vulnerability of society increasing or decreasing?; (2) to what degree should we prepare societal disaster plans to deal with reduction of consequences and societal disaster plans; (3) the effects and consequences of surprise impacts, near misses/close encounters, and failed or uncertain predictions; and (4) do we fully understand the impact consequences?

Lively discussion centered on the degree to which cosmic impact constitutes a substantive hazard for humankind. While impact is understood to be an inevitable part of solar system process, and while most workshop participants felt that cosmic impact is worthy of inclusion on standard lists of hazards confronting modern society, the degree of risk and even aspects of the nature of the hazard are still poorly known.

The next significant impact on Earth, which can happen at any time and would not be identified prior to impact, is most likely to be that of a "small" (a few megatons) asteroid striking water or occurring as an airburst over water. Uncertainties include the frequency and size (in both diameter and megatons) of small Tunguska-like impactors-a hundred years to several thousand years on average between such events, and between 3 to 15 megatons for such an event-and the degree to which a small impactor can generate dangerous local tsunami or local fires in terrestrial settings. These uncertainties, when translated to economic and social values, make it difficult to judge if impacts should be ranked at the low end of the hazard scale, as thought by some of the workshop attendees, or should be given a more prominent role in the hazard scale and in societal disaster planning.

Larger impactors capable of regional or global consequences were uniformly conceived to be devastating for human society, unlike any other historic natural disaster within the past several thousand years. Although considered very low probability events (on average between tens to hundreds of thousands of years), it was stressed that such larger impactors still can happen at any time. As with smaller impactors, there was considerable uncertainty as to the size and thus frequency at which a large impactors can minimally inflict global consequences in terms of regional devastation, climate change (such as ozone depletion), economic catastrophe, and other social parameters. The minimal size (diameter) range was suggested at being somewhere between approximately 500 m to 2 km. Also debated was the potential of large impactors and moderate-sized impactors between about 200 to 500 m to create mega-tsunami. Comets were modeled as representing only about 4% of the population of potential hazard NEOs.

The frequency and hazard uncertainties for both small and larger objects also translated to uncertainties in the economics of actively searching for potential hazard objects, and for devising possible deflection/mitigation programs. Current surveys for asteroids larger than 1 km in diameter have documented approximately 65% of such objects, with the expectation that 90% will have been discovered within ten years. This search costs about $4 million U.S. dollars per year. It is estimated that a search for objects down to about 100 m, slightly larger than Tunguska, would cost about ten times as much during this period of time. Cosmic impact differs from other natural disasters in that if specific impact threats are identified, the consequences can be reduced by prediction of the location of impact (a currently difficult task for impacts occurring shortly after discovery) and disaster preparedness, or eliminated entirely by deflection given adequate time and technology. The question becomes whether or not the hazard is of sufficient degree to warrant vigorously active disaster planning and deflection research.

Particularly contentious, but of direct bearing on the issue of hazard degree, was archaeological, anthropological, and geological evidence presented by three different participants for three different regional/globally catastrophic comet impacts during the past 5000 years. The validation of any one of these events would strain current cosmic

impact hazard models, while two likely would necessitate major revisions to current hazard models. Most workshop participants were intrigued by although quite skeptical of these data. Fortunately, these Holocene period impact hypotheses are amenable to testing and verification, and thus can be resolved in the near future.

Regardless of the risk and economic/social economic consequences of impact, it was realized that the communicating and reporting of cosmic impact information is often poor and haphazard. The sciences, media, and general public often use different terms to describe the same or similar types of phenomena and physical behavior, or attach different meanings to specific words and terms. For example, there is considerable confusion between science and the public as to what is meant by relatively simple terms such as "prediction," "probability," and "risk." These semantic confusions also exist between the physical sciences and the social sciences. Also, there currently are few meaningful standard protocols for responsible astrophysical organizations to advise other appropriate organizations and agencies, or to advise international organizations and foreign governments of impending specific probable impacts.

A clear sign of the intensity of workshop discussions and the serious demeanor of workshop participants was evidenced by the flurry of e-mails and commentary on a variety of topics in the weeks following the workshop. I have never been involved in a workshop/symposium where there was so much excellent dialog after the event itself. Certainly the workshop was successful in breaking down at least some of the barriers that have existed between our various disciplines.

The results of the workshop are to be released in two formats. The first will be a "white paper" summarizing the current scientific understanding of the whole range of issues that were discussed and identifying areas where further research is particularly needed, and formulating the conclusions in the form of recommendations to national or international organizations responsible for setting the relevant policies. The second will be a peer-reviewed book of participant papers to be published later this year by Springer-Verlag. Questions can be directed to Peter Bobrowsky pbobrows@NRCan.gc.ca or Hans Rickman Hans.Rickman@astro.uu.se.

W. Bruce Masse, Ph.D.
Cultural Resources Team
ENV-ECO Ecology Group
Mail Stop M887
Los Alamos National Laboratory
Los Alamos, NM 87545

Telephone: (505) 665-9149
Fax: (505) 667-0731
Email: wbmasse@lanl.gov

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