



How Many People Were Impacted? and How Severely?

Accelerating Situational Awareness with PAGER

Magnitude is popularly used as a shorthand measure of earthquake size and severity. Usually, though, when people assess “how bad” a quake was, they consider not only the size of the earthquake and how hard the ground shook, but also its effects on people and the built environment. Magnitude alone is not a reliable indicator of such impacts.

In 2002, a magnitude 7.9 earthquake struck a sparsely populated region in the southern interior of Alaska, causing no deaths and little damage to structures.¹ The magnitude 7.9 quake that struck China’s densely populated Sichuan province in May 2008, however, killed more than 69,000 people. As these examples illustrate, the impact of an earthquake depends on how many people are exposed to it. Also important is how well protected these people are from the quake. Have most of the buildings where they live and work been built to resist earthquake damage, or are many of them relatively vulnerable to ground shaking?

rapidly gauge the scope of earthquake impacts and plan and prioritize initial response and reconnaissance efforts.

Synergistic Linkages

PAGER is operated at the USGS National Earthquake Information Center (NEIC) in Golden, Colorado. Launched in 2007, the system has linked several existing tools and resources to create innovative new products. The foundations of the system are the seismic monitoring networks operated by the USGS and its partners. These include the Global Seismographic Network, which is supported jointly by the USGS and the National Science Foundation, and the USGS Advanced National Seismic System.

The monitoring networks detect earthquakes and generate near-real-time data on their locations, magnitudes, and other parameters. PAGER feeds these data into USGS ShakeMap technologies to estimate and map the levels of ground shaking expected across impacted areas. The system then

integrates these findings with population data to estimate how many people, in which cities, were exposed to the calculated levels of shaking. The population and settlement data are obtained from Oak Ridge National Laboratory’s LandScan population database and from GeoNames, a free global geographic database.

Estimated Population Exposed to Earthquake Shaking

ESTIMATED POPULATION EXPOSURE (k = x1000)	--*	--*	192,012k*	89,480k	15,484k	12,396k	4,301k	692k	603k
ESTIMATED MODIFIED MERCALLI INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+
PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	Resistant Structures	none	none	V. Light	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy
	Vulnerable Structures	none	none	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy	V. Heavy

*Estimated exposure only includes population within the map area.

Population exposure table from the PDF summary of PAGER results (Version 1.1) for the magnitude 7.9 Sichuan, China, earthquake of May 12, 2008. Source: USGS.

The U.S. Geological Survey (USGS) Earthquake Hazards Program, which is the USGS component of the National Earthquake Hazards Reduction Program (NEHRP), has developed a tool that can be used to more quickly and reliably assess the probable impact of earthquakes. Immediately following significant quakes occurring anywhere in the world, this automated system, named PAGER (Prompt Assessment of Global Earthquakes for Response), estimates how many people and identifies which cities have been exposed to shaking of various intensities. It also describes, where possible, the general level of vulnerability of buildings in the affected region. PAGER is intended to help government agencies, emergency relief organizations, and the media

PAGER results are generated automatically for magnitude 5.5 or larger earthquakes occurring anywhere in the world, as well as for some smaller quakes occurring in the United States. Normally within 30 minutes of such quakes, the NEIC posts initial results on the USGS website’s PAGER webpages (<http://earthquake.usgs.gov/pager/>) and sends free summary results, called PAGER alerts, to subscribers via e-mail or mobile text messaging.

PAGER subscribers currently include about 100 representatives of national and international agencies and organizations ranging from the White House, the Department of

¹ Gary S. Fuis and Lisa A. Wald, 2003, *Rupture in South-Central Alaska—The Denali Fault Earthquake of 2002*: U.S. Geological Survey Fact Sheet 014-03 (<http://pubs.usgs.gov/fs/2003/fs014-03/>).

Homeland Security, the State Department, and the U.S. Air Force to the United Nations, the World Bank, the Mercy Corps international relief organization, and the Thomson Reuters news agency. Of particular note is the U.S. Agency for International Development, whose Office of Foreign Disaster Assistance has provided grant funding and technical assistance for PAGER development.

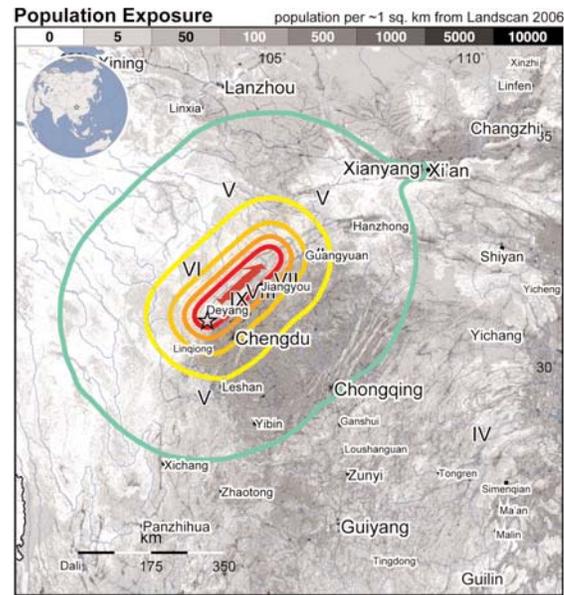
PAGER Products

There are presently four components in PAGER alerts: population exposure tables, population exposure maps, city exposure tables, and regional commentaries. These can be viewed on or downloaded from the PAGER webpages for any earthquake processed by the system since September 1, 2007.

PAGER's population exposure tables use the Modified Mercalli Intensity (MMI) Scale. The tables specify, for each of nine MMI values, the total population exposed to that level of shaking intensity, the expected strength of shaking at that level, and the degree of damage expected for both earthquake-resistant and vulnerable structures at that level. In the accompanying population exposure maps, the areas that experienced each level of shaking are contoured on a map that shows, using grayscale shading, population densities within these areas.

Cities within the mapped areas are listed in the city exposure tables; the population of each city is provided along with the estimated MMI level to which residents were exposed. The regional commentaries are paragraphs whose content varies depending on what information is available. They usually include a statement about the general vulnerability of buildings in the affected region, and may include information on the impacts and population exposure of previous earthquakes in the area.

ShakeMaps, which map MMI values across affected regions using a continuous color scale, are also included in the PAGER results produced for each earthquake, as are the quake parameters of location, magnitude, date, time, and depth. As the NEIC receives additional data in the hours following a quake, it typically generates updated versions of PAGER products for that event. These sequentially numbered updates reflect the incorporation of additional monitoring data, information about the fault rupture, and firsthand reports of shaking received via the online USGS *Did*



Population exposure map from the PDF summary of PAGER results (Version 11) for the Sichuan earthquake. Source: USGS.

You Feel It? system (<http://earthquake.usgs.gov/dyfi/>). Conveniently, the PAGER webpages provided for each quake include a summary of results that can be downloaded as a one-page PDF document.

The USGS is conducting research with the aim of eventually supplementing current PAGER products with estimates of expected casualties and property losses. Initial work now under way is focused on fatalities, which may provide a more direct, intuitive measure of an earthquake's impact than does population exposure, whose meaning can vary depending on the level of earthquake vulnerability prevailing in the built environment. The USGS is also looking at how to link PAGER to the agency's Earthquake Notification Service (ENS), which would facilitate broader distribution of PAGER products. The ENS is a free service that sends immediate notifications of earthquakes to 130,000 subscribers worldwide who are able to customize how and when they receive ENS messages (<http://earthquake.usgs.gov/ens/>).

Further information about the PAGER system and links to the results that have been generated for specific earthquakes can be found at <http://earthquake.usgs.gov/pager/>. Organizations interested in subscribing to PAGER alerts should contact Paul Earle (pearle@usgs.gov) or David Wald (wald@usgs.gov) at the USGS.

For more information, visit www.nehrp.gov or send an email to info@nehrp.gov.