



QUAKE CATCHER

WITH EARTHQUAKE DEATH TOLLS RISING, ROSS STEIN IS BUILDING A GLOBAL RISK MODEL TO MITIGATE FUTURE DISASTERS.

BY JOANNE BAKER

In a darkened room in Pavia, Italy, a jumble of stubby arrows spreads out across a large screen like a swarm of ants on the march. To Ross Stein, the marks on this map of the Balkans reveal where earthquakes are most likely to strike, and he urgently wants to share what he sees.

Stein, a geophysicist with the US Geological Survey (USGS) in Menlo Park, California, jumps up from his chair and runs his hand in an arc down the map. Seated in the room are eight seismologists from the former Yugoslav republics and Albania who are analysing their data together for the first time. Ross explains to them how compression is thrusting rocks upwards along faults in some areas and pushing them sideways in others. That pent up energy could be released in devastating tremors, he says, just as it was in July 1963 in Skopje, Macedonia, killing more than 1,000 people.

Such a comprehensive view of the quake risks in the Balkans has been missing, in part because researchers there have limited funding and because some nations prefer to sell geological data rather than disseminate it for free. Two of the workshop's participants, from Slovenia and Albania, are long-time collaborators who could not afford to meet face-to-face in the past decade.

Stein aims to change all that — in the Balkans and elsewhere — by bringing people and data together. He is one of the leaders of the Global Earthquake Model (GEM), an ambitious project to build an open-source digital network of databases and tools focused on seismic dangers around the world. By helping nations, businesses and researchers to assess and minimize risks, Stein hopes to counter the conditions that have led earthquake death tolls to rise over the past century as cities — many with poor building practices — have swelled in quake-prone regions.

After more than five years in development, GEM is nearing major milestones. Next week, the project will release a database of quakes that have occurred over the past millennium, along with a basic version of its software engine, OpenQuake, which will allow users worldwide to calculate their vulnerability to seismic shocks. In December, GEM will unveil a list of all known active faults in the world.

JAMES BROWN/FROM J TO B

“You’d think that our community would have an inventory, but no one’s tried to build one,” Stein says. “That’s what GEM plans to do.”

Over the course of 2014, GEM will add in information about buildings and socio-economic indicators, such as poverty, which could help cities such as Istanbul in Turkey decide how to prioritize the strengthening of vulnerable schools and hospitals.

“It’s extraordinary to me how much they have accomplished,” says Lori Peek, a sociologist and co-director of the Center for Disaster and Risk Analysis at Colorado State University in Fort Collins, whose research has informed the project.

Leading the GEM effort has marked a major career shift for Stein, a well-respected researcher who has frequently appeared in the media warning citizens about quake risks in the United States. Now he is on a much bigger stage, trying to drum up support for this international project from scientists, governments and companies. “It’s been quite an education,” he admits.

And it is far from over. Stein must still complete GEM and demonstrate its value. Some critics charge that the effort will not save many lives by offering more sophisticated assessments of seismic risk. Roger Bilham of the University of Colorado at Boulder says that corruption, ignorance and poverty are much greater barriers to safety than lack of information about quakes.

STRESSFUL START

Stein, 59, got his first big taste of seismology as a teenager in Los Angeles, when “terra firma became jello” during the 1971 San Fernando Valley quake, which killed 65 people. But he did not settle on studying Earth science until his college room-mate at Brown University in Providence, Rhode Island, introduced him to the joys of field trips. Stein started a doctorate in glaciology at Stanford University in California and endured the “coldest, wettest, windiest fieldwork”. Then, wanting to pursue a topic with social impact, he switched to earthquakes after hearing a talk from a USGS scientist. He joined the agency in 1981.

In his research, Stein has focused on how an earthquake in one spot transfers stress to other regions. His modelling efforts have provided a means of estimating whether tremors will increase or decrease the likelihood of earthquakes elsewhere.

That and other work, notably in Turkey and Japan, made Stein the second most highly cited earthquake scientist from 1993 to 2003. And his impact has spread far beyond the research community. He has appeared in numerous documentaries and is often in front of a camera after a large quake.

Stein’s research trajectory was drastically altered by the 2004 Sumatra–Andaman earthquake and tsunami, which killed more than 230,000 people in 14 countries. That event, he says, “crystallized our failure as a community” by revealing how little scientists had done to help the region to prepare for the hazards expected in that area. “In some ways I felt there was blood on my hands,” says Stein.

He decided that it was more important to address seismic risks in poor countries than in California or Japan, where a long tradition of research and strong building codes has already reduced dangers. From Jakarta to Port-au-Prince, urban populations are skyrocketing near major faults and along tectonic-plate boundaries. The influx of people is filling poorly constructed houses that become death traps in quakes, Stein says. Seismologists predict that, before long, a large shock will kill a million people.

In 2006, after an earthquake workshop in Potsdam, Germany, Stein and two other seismic-risk experts — Jochen Zschau at the Helmholtz Centre in Potsdam and Domenico Giardini of the Swiss Federal Institute of Technology (ETH) Zurich — decided to combat that trend by setting up GEM.

A raft of international, governmental and non-governmental organizations already helps at-risk communities to prepare for and respond to quakes, but those efforts are fragmented. The Office of US Foreign Disaster Assistance (OFDA), which sponsored Stein’s

Balkan workshop, helped to develop a tsunami warning system in Indonesia after the 2004 event and is running seismic projects in Haiti and the Dominican Republic. And GeoHazards International (GHI), a non-profit organization based in Menlo Park, has worked in more than 20 countries to raise awareness and train construction engineers in quake safety. But no single organization can span every town and city, and no country can afford to reinforce or insure every building. Knowing where risk is highest is key, Stein says.

Information is also splintered. Peek, who advises the GHI, participated in a study for the GEM consortium that showed that communities from San Francisco, California, to Chinchu in Peru all need a central resource on earthquake risks — one that pools data on seismic threats, construction issues, and economic and social factors. That would help local officials to prioritize which public buildings or regions to strengthen, and allow emerging cities such as Kathmandu or Lima to plan how to grow without increasing their seismic risk.

GEM aims to provide that resource through OpenQuake. Built using a geographical information system, this platform will include analytical tools that allow anyone — scientists, governments and companies — to estimate the chances of economic and human losses from earthquakes (see “Trouble spots”).

The calculators will draw on the GEM’s global databases of quakes, faults, housing types and socio-economic information, which are being rolled out over the next 18 months. In January, GEM released a reference catalogue of more than 20,000 global earthquakes of magnitude 5.5 and above that have occurred since 1900. To produce it, the consortium reanalysed all the seismic data involved, improving estimates of earthquake epicentres and magnitudes. It is the biggest resource of its type and has allowed seismologists to see, among other things, how seismic activity concentrates on a major fault below Guatemala, says Stein.

To get the project off the ground, Stein and his collaborators had to persuade funders to back the plan. The Paris-based Organisation for Economic Co-operation and Development (OECD), which sponsored the Potsdam workshop where the GEM idea was seeded, gave

“WE WILL FACE ABUSE. SOME GOVERNMENTS WILL PUSH BACK AGAINST GEM’S ASSESSMENTS.”

Stein and the founders access to governments officials. In the wake of the Sumatran tsunami and a major quake in Pakistan, OECD member states in high-risk regions wanted to minimize their exposure to giant economic losses.

Stein’s contacts grew from there. In 2007, Munich Re became the first company to get involved, giving €5 million (US\$6.6 million) over five years. It saw an opportunity in the global data being collected by GEM, which could help insurance companies and reinsurance brokers to diversify their portfolio to avoid being wiped out by a single earthquake.

Today, 16 governmental agencies, such as the OFDA, and 10 insurance and engineering companies have joined GEM, which is a non-profit public–private partnership headquartered in Pavia and has some 20 staff. These sponsors have contributed more than 90% of the €24 million needed to release the full OpenQuake platform, which is planned for November 2014. In addition, nine organizations, including the World Bank, have become associate non-paying members.

Dealing with the disparate interests has been a steep learning curve for Stein. “All have a stake,” he says, and “issues to champion”. At GEM board meetings, he says, the different sectors sit in groups around a U-shaped table — the countries on one arm, companies on the other and the non-governmental organizations in the centre.

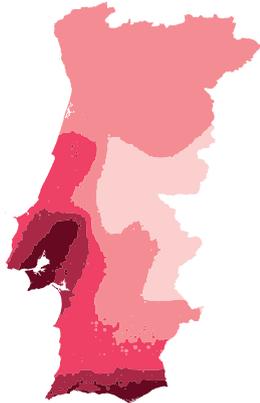
Some scientists, however, are unhappy that companies have a seat at the table at all. “Suppose you could manipulate hazard forecasts to

TROUBLE SPOTS

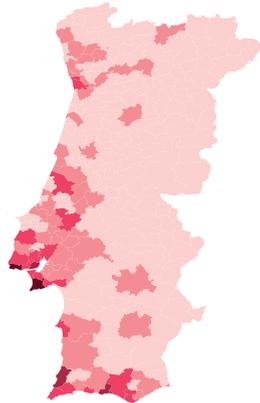
The Global Earthquake Model has tools to assess earthquake risk by combining data on ground shaking, construction practices and socio-economic vulnerability. An example from Portugal shows the integrated risk from a magnitude-8 earthquake such as the one that destroyed Lisbon in 1755.

SOURCE: GEM

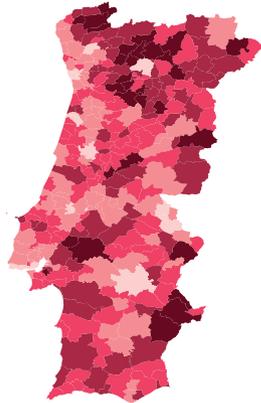
SEISMIC HAZARD FROM GROUND SHAKING



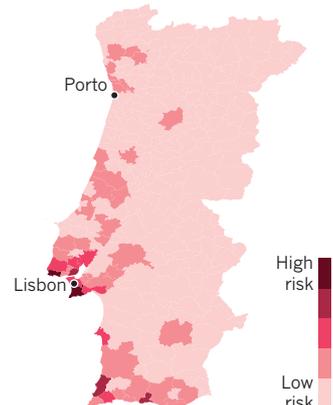
ECONOMIC LOSS FROM BUILDING DAMAGE



SOCIO-ECONOMIC VULNERABILITY TO DISASTER



INTEGRATED EARTHQUAKE RISK



justify higher quake-insurance premiums in built-up areas,” muses Robert Geller at the University of Tokyo. But Stein is pragmatic. “If you are talking to a finance minister you have to talk about economics or they won’t pay attention,” he says.

To be widely used and trusted, Stein says that GEM must be seen as independent, transparent and accessible. That’s why OpenQuake uses open-source software — and why GEM plans to give away the project’s data and products to anyone, including the public, scientists and governments, if they are engaged in non-commercial work. Companies wanting to use the data commercially will need to sponsor the organization. Governmental agencies are asked to make a contribution that is proportional to their total investment in research and development. For Ecuador, that runs to €15,000 per year, whereas Germany is paying €275,000 annually.

The founders hope that banks and companies will join in order to build new markets or products. They could use GEM data and tools to develop ‘catastrophe bonds’, a type of insurance in which investors take the risk in return for payments if a specified event does not occur. Companies have offered such bonds since the mid-1990s, but governments are now getting in on the act. Earlier this year, a group including the Turkish government issued a bond that will release US\$400 million if Istanbul experiences a major shock in the next three years.

SCIENCE DIPLOMACY

Stein, who chairs GEM’s scientific advisory board, has to do more than marshal the seismic data and models. He is part of the human glue that melds the sectors together, a post that requires the skills of a diplomat and a salesman.

Both skill sets were on display at the Balkan workshop, where the assembled seismologists began arguing over funding inequities and other problems in previous regional initiatives to analyse earthquake risk. At one point, some participants shouted at each other across the table. Stein let them have their say and then stepped in to calm the waters. He asked each in turn to express their views and offered to visit each country that autumn, to convince government officials and university heads to back the researchers.

As GEM becomes more visible, Stein knows that he will have to contend with critics. Some members of the seismology community say that it is misleading to map hazards on the basis of past earthquakes because the historical record is too short, and large earthquakes often occur where none has previously been witnessed. In northeastern Japan, for example, risk maps for the Tohoku region did not anticipate a monster quake of the size that struck in 2011.

Other researchers, such as Bilham, question whether the project’s engineering goals will ever be enacted; they argue that many countries already have adequate building codes but fail to enforce them — so better risk models won’t help.

Stein has dealt with some of the criticism by inviting naysayers to participate in GEM. Seth Stein (no relation), a seismologist at Northwestern University in Evanston, Illinois, who is a long-standing opponent of some seismic-hazard maps (see *Nature* 479, 166–170; 2011), attended a GEM workshop. Although Seth Stein sees GEM’s open-source, standardized and modular approach as “a good step in the right direction”, he also hopes that the seismology community will take advantage of the resource to do broader analyses exploring the limitations of seismic-hazard analysis.

Looking forward, Ross Stein seems most concerned about securing funding. GEM will need more subscribers to pay for the curation and updating of its databases in the future and is seeking a further €10 million to fund allied regional programmes to enhance the local detail of the risk databases. To attract and retain sponsors over the long term, the project must keep rolling out useful features on related risks — such as models including tsunamis, landslides and liquefaction, which happens when seismic shaking weakens soil to a point at which it begins to behave like a fluid.

The most difficult challenge long term, however, may be handling the backlash over risks identified by GEM. Stein says that GEM “is not an advocacy organization” and will not get involved in policy decisions on the basis of its assessment. Even so, “we will face abuse”, Stein accepts. “Some governments will push back against GEM’s assessments because they differ from their priorities.”

In Pavia, as the Balkan workshop winds up, Stein practises the diplomatic skills he will need to make GEM succeed. Moving beyond the earlier rancorous discussion, he suggests that all the participants write a joint publication and apply to the OFDA for funds to enable them to meet again in six months. All the seismologists pledge to continue the collaboration. Such a meeting will be essential “if we want to build a harmonized model for the whole Balkan area”, says Barbara Sket Motnikar of the Jožef Stefan Institute in Ljubljana.

Three weeks later, the OFDA agrees to fund a second workshop for the group. The decision underscores some of Stein’s parting words to the Balkan seismologists: “Never underestimate the power of your enthusiasm.” ■ [SEE EDITORIAL P.271](#)

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