PLANNING AND GEOHAZARDS

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INTRODUCTION

Fifty six papers were accepted for the Geohazards and Planning Theme of the 10th Congress of the International Association for Engineering Geology and the Environment. Authors from sixty different countries successfully submitted papers, with particularly strong representation from China, Brazil, Russia and Turkey (Fig. 1.). Due to the popularity of this Congress theme, it has not been possible to summarise all of the papers accepted, or indeed fully represent the breadth of research contained within individual works. Selected papers are considered here as representative case studies to illustrate state of the art research and developments pertaining to different geohazards (Table 1), and also the topics of risk modelling, urbanization as the cause of hazard, and mitigation techniques.

Figure. 1. Geographical distribution of papers submitted for Planning and Geohazards Theme.

SESSION DISCUSSION

Most of the discussion centred on the assessment and management of hazard and risk. Increasing frequency of natural disasters was acknowledged as an alarming and challenging development all over the world, especially in less developed nations. It was highlighted that the causes for this are complex. The discussion included anecdotal reports to support an increasing temporal frequency of high magnitude hazard events – a pattern that may be related to climate change and other phenomena. Importantly, population rise means that many areas of urbanization are now encroaching into marginally or entirely unsuitable land. The exposure to hazards and vulnerability of people, housing, industry and infrastructure are increasing. Poor planning and inferior construction in poorer and less developed countries increase their vulnerability and the consequences of hazard events. The discussion concentrated on the fact that, with these two trends, an increase in frequency and magnitude of urban disasters is bound to occur.

Risk 'management' carried out after an event often proves to be inadequate in the short-term and ineffective or even counter-productive in the long-term. Often, significant losses from a natural disaster are followed, after another few years, by a disaster of comparable or greater severity. Thus, there is an urgent need for more innovative approaches to hazard assessment and to risk management. Importantly, urgent consideration must be given to 'preventative risk management'. This should include careful planning for the medium to long-term, strict control on the extent and intensity of development, appropriate instrumentation and monitoring, early warning systems and a variety of engineered solutions to specific problems. Adoption of such measures in advance of the occurrence of potential natural events would, of course, involve significant expenditure but this should be presented as key investment, the benefits of which could be enormous. Conversely, failure to invest will result in lost opportunity and potentially catastrophic loss.

It was broadly agreed that preventative risk management incorporating a variety of tools, techniques and methodologies should be adopted for reducing the frequency and severity of disasters and other adverse natural events. Even for a strategy embracing 'preventive risk management', it is necessary to put in place a reliable hazard-vulnerability-consequence framework. It was agreed that engineering geologists have a crucial role in this process. However, to maximise the benefit to the community, engineering geologists must continue to develop new avenues of communication, working alongside planners, economists or politicians.

Table 1. *Research Topics of the papers accepted for the Theme Geohazards and Planning*

Geohazard Theme	Paper Number
Earthquakes	106, 236, 242, 256, 262, 293, 305, 317, 318, 361, 362, 410, 424, 449, 457, 563, 587, 753, 760, 763
Landslides	114, 154, 169, 173, 324, 449, 470, 502, 513, 535, 624, 644, 712, 779, 784, 790, 796, 806, 818
Karst	247, 262, 282, 353, 410, 449, 573, 801
Settlement	114, 262, 294, 449, 465, 502, 712, 786
Soil erosion	139, 145, 449, 465, 502
Flooding	154, 282, 737, 760
Collapsible soils	196, 294, 324

Shrink-swell	410, 465
Volcanoes	114, 624
Fissuring	596
Undermining	262
Contamination	293
Radon	554

EARTHQUAKES

Twenty papers with a central theme of seismic hazard were submitted. Most concentrate on building seismic hazard scenarios at a city scale, using microzonation and GIS techniques. Maksud Kamal & Midorikawa (2009) described a microzonation study for Dhaka, Bangladesh. Combining a new geomorphological model with the results of a seismic velocity survey of the city, they were able to define three areas where ground conditions and building height combined to form discrete areas of relatively high risk. The results of their study have been used to support a proposed process to retrofit buildings at particular risk. Similarly, a study by Kocbay & Orhan (2009) highlighted areas where the weak nature of lake sediments near Lake Efteni, Turkey, resulted in an increased liquefaction potential.

Several studies were presented concerned with establishing ground motion amplification patterns associated with superficial or artificial deposits. Ohta *et al*. (2009) developed a model utilising borehole records and other information to assess liquefaction potential for the city of Takamstsu, Japan. This study was supported by that of Saito *et al*. (2009), which described how shallow seismic techniques were used to supplement the borehole information. Their technique determined the S-wave velocity profile of the ground using the response from an artificial seismic source. Although the depth of investigation is limited and reliant upon a fair understanding of the subsurface environment, it is non-invasive, compact and cheap. Results presented showed that S-wave profiles related to channel fill or embankments comprising weathered granite were clearly identifiable.

Rebolledo *et al*. (2009) described a study centred on the city of Santiago, Chile and sought to understand anomalous patterns of damage observed following a M 7.8 earthquake in 1985. They presented results from a geotechnical and geophysical investigation, which established a clear ground motion amplification pattern in areas where thick ignimbrite and pyroclastic flow deposits were underlain by fine grained soils. Pergalani & Compagnoni (2009) classified characteristic geological profiles in Lombardia, Italy, according to their likely response to a seismic event. An extensive programme of laboratory testing and modelling of subsurface profiles identified three characteristic successions, of which ‘silt with clay’ was the most susceptible to ground motion amplification.

Liquefaction of alluvial sediments on the shore of Lake Sapanca, Turkey following the Kocaeli earthquake of 1999 was described by Kanibir *et al.* (2009). Substantial damage was caused to buildings, lifelines and other structures, many of which were affected by lateral spreading towards the lake. They developed a series of empirical models based upon seismological, topographical and soil property data, which accurately simulated observed ground deformation.

Other researchers drew attention to areas where the seismic hazard may be underestimated and further research is required, often because the regional model of seismicity does not take local conditions into account. Ghanbari & Jalili (2009) reconsidered the earthquakes affecting the North Tabriz fault, which is rupturing progressively in a westward direction. Their assessment of the seismic history of the fault since the 17th Century suggested a recurrence interval for destructive earthquakes that would justify the microzonation of Tabriz and other cities within Azerbaijan, regions of the Caspian basin and Iran. The related study by Ghanbari *et al*. (2009) supported this research. Çabalar (2009) considered the possibility that existing seismic models of Gaziantep, Turkey, might underestimate the hazard posed by the Dead Sea Fault Zone as well as the more heavily studied North Anatolian Fault. Jamali *et al*. (2009) presented a preliminary evaluation of the seismic hazard in Fujairah Emirate and recommend further study.

Fenton (2009) highlighted the need, in many instances, to consider site-specific hazard. He presented a methodology that can be applied when a detailed site study to properly establish the 3D architecture of a rupture system is not feasible. The technique described takes advantage of the fact that, in tectonically active regions, surface faulting often occurs on existing faults, with deformation reducing with distance from the rupture. His paper demonstrated that a rupture zone map, indicating probability and extents of movement, can be made using pre-existing records and, crucially, *professional judgement*. The maps have been used to communicate the problem to engineers, aiding the design of seismic protection features. As with many papers presented and accepted in this theme, the solution was a pragmatic compromise which seeks to reduce risks using the best available information.

LANDSLIDES AND EROSION

Landslide specific studies included that of Zhou (2009), who described a case study for the Baota landslide on the banks of the Yangtze River, China. This ancient landslide has been subject to local reactivations since 1984 and poses a significant threat to several new developments. An extensive monitoring programme was developed that used several different techniques, with special attention paid to groundwater. Careful monitoring of pore-water pressure, temperature and chemistry revealed a complex relationship between movement, rainfall and the elevation of the river. The Three Gorges Dam has been designed to enable annual fluctuations in water depth of up to 45 m, to allow safe entrapment of flood waters. Aware of the potential impact of this variation in head on the stability of pre-existing landslides, Mo & Yuhu (2009) carried out a detailed study along a stretch of land containing a selected number of landslides. Computer modelling of slope stability along this stretch under different scenarios was used to inform local development plans.

Zenóbio & Zuquette (2009) described work to help engineers and planners involved in the expansion of urban zones into unstable, weathered slopes in the Serra de Ouro Preto region in Brazil. They carried out extensive geotechnical mapping and geotechnical testing of materials and combined these with assessments of natural slope instability to produce zoning charts for use by non-geological professionals. The Sao Pedro and Barra Bonita region of Sao Paulo is extensively affected by landslides, gulleying and soil loss. Ferreira & Pejon (2009) described how an understanding of these issues required an extensive knowledge of the engineering geology and hydrogeology in the three separate watersheds.

KARST

Schmitz & Schroeder (2009) presented two case studies of how early involvement in construction projects by engineering geologists has greatly assisted in major construction projects in karst terrains. One of these involved the Soumagne tunnel, part of a new railroad from Brussels, via Liège and Aachen, to Cologne. The tunnel cut through a series of limestones known to show palaeokarst. Site investigation techniques included borehole, geophysical, geotechnical and hydrological measurements, a pilot gallery, microgravimetric measurements and advance drilling. The basic ground model was applied to determine appropriate site investigation and construction techniques to identify potential karst problems for the duration of the construction project.

Török *et al*. (2009) presented a review of the impact of karst on cities and went on to compare the relative impact of karst in Hungary and Greece. The comparison is a useful one, as it allows comparison between Hungary, affected by a relatively small area (4.4%) of uncovered karst, as opposed to a country which has nearly a third of its surface area covered by limestone but with a generally subsurface karst. They described the major engineering challenges posed by subsurface karst that often lead to water intrusion, overbreaks, instabilities and other challenges. For the examples presented, they demonstrated that Greek karst is often related to discontinuity-controlled water flow or instability, whereas the karst of Hungary is more closely related to the drawdown of the water table caused by urban expansion. The difficulty of assessing thermal karst, which develops upwards and shows very little surface expression until a collapse occurs, was also described.

Anikeev (2009) carried out a series of experiments to investigate the phenomenon of spalling and fissuring of clay materials, which form caps to many karstic voids and fissures and are the main cause of sinkhole generation in a zone of the pre-glacial Moscow river valley. Through a long-standing research programme they have identified a chain of hydrological, suffosion and stress-relief processes that contribute to karst activity and are contributing to a better understanding of the subsidence in the north-west district of Moscow.

SETTLEMENT AND SUBSIDENCE

Ruilin (2009) presented an excellent and detailed review of urban land subsidence in China. He showed that at least eleven cities, including Shanghai, Tianjin and Suzhou have had an accumulative subsidence of greater than 1 m at their subsidence centres. The primary cause of the problem is withdrawal of groundwater by urban and industrial consumers. Although many lessons were leant from these experiences, the author described how the expansion of new industrial cities, currently of "median-size" is expected to lead to similar problems over the next few decades.

A different aspect of subsidence was explored by Ajalloeian *et al*. (2009). They described ground fissuring related to subsidence in the northern Mahyar plain, Iran, which has caused damage to houses, agriculture and highways for the past thirty years. Although the groundwater extraction, which caused the subsidence, had slowed since 1991, ground fissuring had continued. Using 3D modelling techniques, they were able to establish a relationship between the thicknesses of clay units at depth, with the pattern of surface fissuring.

COLLAPSIBLE SOILS

De Oliveira *et al*. (2009). Described how the town of Solteira, Brazil, originally conceived as a temporary development, was built on deposits with a high collapse potential. As the town outgrew its expected lifetime and serviceability, the water supply and sewerage systems leaked, triggering collapses. A risk map was designed from the results of geological and engineering geological mapping, geotechnical testing, a damage register, and resident interviews. A generalized version presented as a risk register map has been used to support maintenance schedules and to raise awareness amongst those affected.

VOLCANIC HAZARDS

Donnelly *et al*. (2009) presented an excellent case study of how engineering geology has proved invaluable to the mitigation of volcanic, seismic and landslide hazards on the Caribbean island of Montserrat. The Soufrière Hills volcano has been in a state of eruption for ten years, necessitating the evacuation of the majority of islanders and relocation of primary infrastructure. A review of activities since 1995 demonstrated how volcanic risk maps of the island have evolved with changing volcanic activity and population.

Williams *et al*. (2009) described a volcanic problem of distinctly different scale and nature to that of Montserrat, the potentially active Auckland Volcanic Field, upon which the metropolitan area of Auckland (population 1.3 million), New Zealand stands. Unlike the relatively well-defined hazards described by Donnelly *et al*. (2009), engineering geologists in Auckland are faced with volcanic hazards that might exhibit uncertain spatial extent and little antecedent activity. There is also the likelihood of an extended period of eruption, complex secondary hazards and a relatively unprepared urban area. To counter this potential threat, a volcanic contingency plan has been prepared. The plan includes transparent policies for a warning system, scenario-driven models of hazard and risk, protocols for civil emergency, the allocation of resources and an education programme.

RADON

Only one paper, by Miklyaev & Petrova (2009), was presented on radon hazards. They described a new hazard map for Moscow which combines analyses of radon readings with new engineering geological maps. A survey was carried out in the 1990s that showed 68% of city inhabitants were exposed to doses exceeding 20 mSv/year (the dose limit for professionals). Comparison between measured levels of radon and engineering geological maps of the city showed that areas of high radon readings correlated with areas underlain by clay strata. Investigation of these results revealed that the elevated readings were not because of specific radiative sources but were the effect of high background levels resulting from elevated levels within clay strata. Hence, the engineering geological map provided a good indication of the radon hazard in the city.

HAZARD TO RISK

A significant theme of the papers submitted to congress was the prevalence of risk-based methodologies and the pragmatic approach required for such research. Risk methodologies are crucial to provide comparisons of vulnerability across different hazards and at different scales. Asef (2009) presented an excellent paper that used a normalized scale that expressed the relative impact of earthquakes in different countries. He used this national earthquake vulnerability index to assess and rank 35 nations according to their vulnerability. In every analysis, Iran was demonstrably the nation most vulnerable to earthquakes. Other highly vulnerable countries in the list were China, Turkey, Italy, Japan, and Indonesia.

Many obstacles are currently in place for those attempting quantitative risk analysis. Miner & Dahlhaus (2009) demonstrated that the wide range of methodologies available to risk assessment means that it is difficult to compare the results of different studies. Whitworth *et al*. (2009) showed that many methodologies are biased towards urbanised areas, to the detriment of rural locations. Asté (2009) described some of the problems of obtaining and using quantitative *economic* data as the basis for an assessment. He proposed that the standardised collation of such information is crucial to ensure compatibility with other assessments and application to other uses. Russian legislation will require a risk-based assessment within building design by 2010. Ragozin *et al*. (2009) described progress towards this and how many large or critical constructions have already been assessed in this way. However, they still highlight the significant difficulties in obtaining data for such calculations and non-standardised mechanism of calculating risks. The notion of collecting simple, standardised, updateable data to support risk assessment was further emphasised by Castro Junior (2009) and Marchiori-Faria *et al*. (2009). The latter of these studies also demonstrated the value of remote sensing information as a way of achieving this and of enabling simple risk zonation.

URBANIZATION AS A CAUSE/TRIGGER

Perhaps unsurprisingly, urbanization is repeatedly shown to be the cause of, or contributing factor to, many hazardous situations. Ragozin *et al*. (2009) described how less than 1% of urbanized areas in Russia were affected by rising groundwater levels in the late 1950s, yet currently the figure stands at about 20%, and how over 40 karst collapses have been recorded in Moscow since the 1960s, whereas prior to that, they were unknown. Zhang *et al*. (2009) explained how water extraction, alongside undermining, has exacerbated subsidence in Nanjing, China.

According to Makovetsky (2009) leakage from water pipes from a large Russian city could total 10,000 m^3 per day, and can cause significant problems. This situation has been exacerbated by the widespread cessation of maintenance in the 1990s, contributing to 960 out of 1092 cities suffering groundwater flooding. The flooding is associated with secondary hazards including suffosion, instability, chemistry changes, increased dampness, and aggressive ground conditions. Ragozin (1994) suggested that damage from suffosion, alone, can be observed in 958 towns and cities across Russia, with an approximate annual average economic cost of about $0.5bn at 1990 prices. Khomenko (2009) related these failures directly to leakage. De Oliveira *et al*. (2009) described how leaking pipes (that have exceeded their design capacity and lifetime) have caused extensive soil collapse in Solteira, Brazil. Zuquette & Palma (2009) demonstrated how the pattern of infiltration and overland flow in the Córrego do Vaçununga basin, São Paulo, had been altered by changes in land-use.

The seismic vulnerability of the Anthoupoli district, Athens, has been exacerbated by extensive undermining by coal extraction. Rozos & Kynigalaki (2009) described how damage caused by earthquakes in 1981 and 1999 were more serious here than elsewhere in the region. Extensive research, including data review and widespread ground investigation, has been carried out to determine the extent of the problem. The results of this have been output as a risk map, building guidance and a list of areas where microzonation would be appropriate. This research also highlights the problems of elderly building stock which may not have always been properly maintained, a point reinforced by Petermans *et al*. (2009).

Some authors presented studies where significant geohazard impacts have been factored in to development plans. Huang *et al*. (2009) showed that the city of Kunming, China, is expected to expand from 180 km^2 in 2003 to 460 km^2. This will involve the ‘consumption’ of all available flat lying areas of lake sediments in the vicinity and will drastically change the local hydrological regime, including cutting the entire supply of water to Lake Dianchi. It is anticipated that subsidence will affect 3681 km^2, severely affecting the groundwater system in the West Sichuan Plain. The effects of this subsidence will be irreversible. Similarly, the development of the Three Gorges dam has required the relocation of an entire town within an area prone to multiple hazards. Wu *et al*. (2009) described some of the engineering geological investigations carried out to support such development.

URBAN GEOHAZARD PLANNING

A range of methods were described by which engineering geological expertise could help planners and developers to better manage geohazards in urban areas. The largest, in terms of scale at least, was presented by Zhang *et al*. (2009), who described the mechanisms used to manage hazards in Nanjing City, which, in the future, is expected cover an area of 6516 km^2. The city is affected by landslides, subsidence, undermining, karst and fluvial erosion. Planners have divided the city into 6000 1 km^2 pixels, each of which is attributed in a Geographical Information System (GIS) with information on geological, soil, groundwater and hazards information. This grid was analysed using an Analytic Hierarchy Process to determine the requirements of different land uses and then by a SWOT (strengths, weaknesses, opportunities and threats) analysis to determine appropriate land-use. The city has been divided into areas which are considered suitable for industrial usage, human habitation, port/parking or commerce.

Richards & Brynard (2009) presented an excellent paper that described the recently launched National Geohazard System for the Republic of South Africa. The system has been designed to meet the increasing needs of planners, developers and insurers in that country and utilises extensive data holdings maintained by the national geological institute/survey. Interestingly, this paper also goes into some detail regarding the technical, legal and financial issues raised by data-driven national scale assessments.

At all scales, the input of engineering geologists to urban geohazard management seems increasingly to be through the medium of GIS. Amongst the advantages of GIS described were: dealing with multiple hazards (for example, Zuquette & Palma 2009, Ferrer *et al*. 2009), the joining of disparate data (for example, Ben-David & Nachmias 2009, Saket & Aghda 2009), the ability to incorporate a decision support or warning system (Osipov *et al*. 2009) and the ease with which systems can be modified or updated (Ferreira & Pejon 2009).

Crucially, GIS allows extrapolation of scientific judgement across wider geographical areas (Baptista 2009; Ferrer *et al*. 2009) or the adaptation of engineering advice to answer new questions. This last point was well illustrated by Wassing & Van Der Krogt (2009) who stressed that the final product of an engineering geological survey should *not* be an engineering geological report or map, but an output designed around, and often made with the input of, the end-user. In this example, thematic "subsurface suitability maps" are presented that depict the suitability of areas for a certain spatial development based upon geological *and* socio-economic data.

However, it was clear that GIS is just one tool available to the engineering geologist and the method is reliant upon large amounts of data and expertise (Fall *et al*. 2006). Although most papers in this theme did in some way use GIS, the outputs described included engineering reports, design charts, guidance documents, maps, databases and education programmes. Konno & Nakasato (2009) described a programme of works centred on Sendai City in northeast Japan. Many developments in the city are built on soft foundations and are expected to be affected by an earthquake within the next 30 years. A major initiative to minimize the effects of future events is educating members of the general public. This has involved a series of public lectures and workshops which, over time, will build the knowledge of different sectors of the community and, importantly, give opportunities for feedback. Of particular interest has been the opportunity of participants in the scheme to create their own hazard maps – truly involving them in the hazard management process.

RETROFITTING FOR GEOHAZARDS

Several papers presented research attempting to retrospectively adapt city infrastructure or planning policy (for example, Forster *et al*. 2009, Maksud Kamal & Midorikawal 2009, De Oliveira *et al*. 2009). Loupasakis & Karfakis (2009) described how many long-abandoned limestone quarries across Greece are subject to instability, usually in the form of rockfalls. Problems have arisen where these spaces have been used as public recreation areas. They highlighted a number of areas where engineering geological assessments have been required to retrospectively propose engineering or management solutions to cope with slope instability hazards.

Ground improvement in urban areas often requires special procedures that minimise disruption to surrounding developments or infrastructure. Serridge & Synac (2009) described their Rapid Impact Compaction (RIC) technique, where a relatively light rig applies blows to the ground in rapid fashion. In the case studies presented, this meant that ground could be compacted in close proximity to existing buildings. They also suggested that the technique could be useful in areas where removal of material from the ground would mean handling contaminated material.

CONCLUSIONS

The number of papers submitted to the Congress perhaps allows for further reflection upon how engineering geology and engineering geologists are adapting to an evolving series of challenges. In many respects the papers presented reflect the themes discussed a decade ago by McCall (1998). The primary hazards include earthquakes, volcanoes, slope instability and subsidence; problems are still exacerbated by rapid development, water abstraction, undermining or neglect. A further similarity is that pervasive hazards such as shrink-swell are not highlighted – perhaps a reflection of the type of research required to investigate these hazards, or the perceived relevance of such research to conferences. New development continues to be located in open-space, on slopes or flat lying alluvium, where hazards are greatest (Schuster & Highland 2007). Construction often encroaches upon marginal areas, for instance: coastal plains (Fall *et al*. 2006), unstable slopes (Zogning *et al*. 2007; Castro Junior *et al*. 2009), collapsible ground (De Oliveira *et al*. 2009) or karstic ground (Hu *et al*. 2001). Most problems still seem to arise when rapid expansion of urban areas outstrips the resources available to the planning and enforcement system (Marchiori-Faria *et al*. 2009, Barrett *et al*. 1991), developments exceed their design capacity (De Oliveira *et al*. 2009) or otherwise fail to account for their natural environment (see section on Urbanization). A significant challenge is posed by the planned expansion of towns into the future, where the growth is driven by political or socio-economic factors that outweigh any geoscientific arguments that can be made (for instance Huang *et al*. 2009, Wu *et al*. 2009, Zhang *et al*. 2009).

So what progress has taken place in the past decade? Alongside the utilization of GIS, 3D modelling software and the internet (Chacon *et al*. 2006; Culshaw 2005; Culshaw *et al*. 2006; Osipov *et al*. 2009), the greatest developments in engineering geology over recent years are the increasing adoption of risk methodologies. The past decade has seen a large body of work that provides an excellent framework for risk analysis, for instance Cruden & Fell (1997); Maund & Eddleston (1998); Aleotti & Chowdhury (1999); Dai *et al*. (2002); Lee & Jones (2004); Bird *et al*. (2006). A wide variety of approaches to risk analyses was demonstrated by submitted papers. These often required the combination of geotechnical data and asset data with, for instance, microzonation studies (Maksud Kamal & Midorikawa 2009), damage registers (De Oliveira *et al*. 2009), disaster scenarios (Williams *et al*. 2009) and, to a large extent, the professional judgement of experienced scientists or engineers (Fenton 2009). Much progress is based upon the availability of exemplars of good practice. These may take the form of simple case studies, but may also include comparative studies (for instance Kwong *et al*. 2004) or the open publication of best practice documents such as the widely referenced Australian advice on landslide risk analysis (National Disaster Funding Programme 2007). An issue raised by several authors, including Ferreira & Pejon, (2009) was the need to make *data* available to others in an accessible and useable format, though this often encounters problems of cost and copyright (Richards & Brynard 2009). Sadly, a theme that mirrors some of the findings of the International Decade for Natural Disaster Reduction (IDNDR) is that most progress is made in the aftermath of a disaster (Donnelly *et al*. 2009, Forster *et al*. 2009) or where the hazard is well understood (Ohta *et al*. 2009, Williams *et al*. 2009). Even then, geohazard mitigation is rarely high up the political or international agenda. For instance, the IDNDR was understandably overshadowed by famine in Africa and the Balkan wars (Sudo *et al*. 2000).

It is useful to consider the papers submitted to conference in light of the hypothesis, put forward by Knill (2003) and developed by Culshaw (2005), that engineering geology techniques are now well developed and the profession is now moving towards a period of 'synthesis'. To achieve this, engineering geologists have to make greater efforts to communicate the nature of their findings to support and inform the decisions of other professionals, such as bankers, politicians and planners, many of whom have little interest in understanding even 'basic' concepts (Britton & Lindsay 1995; Phien-wej *et al*. 2006). Crucially, this rarely involves communicating *science*. Instead, geohazard information must be communicated in a palatable manner that is of immediate use and immediate importance to the end-user (Rosenbaum & Culshaw 2003). Otherwise the information will not be utilised and, crucially, the importance of the information will not be appreciated (Marker 2005).

Mora (2007, 2009) suggested that to achieve the greatest impact and help the greatest number of people, the role of engineering geology must now include pro-active movement of the profession's knowledge into the realm of politics, economics and sociology. To a great extent this paradigm shift, of presenting geohazards research in terms of societal vulnerability rather than earth science, has largely been acheived within the volcanological community (Chester *et al*. 2002). In reviewing papers for the Congress, it appears that for radon and earthquakes hazards this shift is well underway. However, there is still significant progress to be made by engineering geologists to make the impact of landslides, erosion, subsidence, karst and collapsible ground an important and serious political and socio-economic issue.

Acknowledgements: This paper is published with the permission of the Executive Director of the British Geological Survey (NERC).

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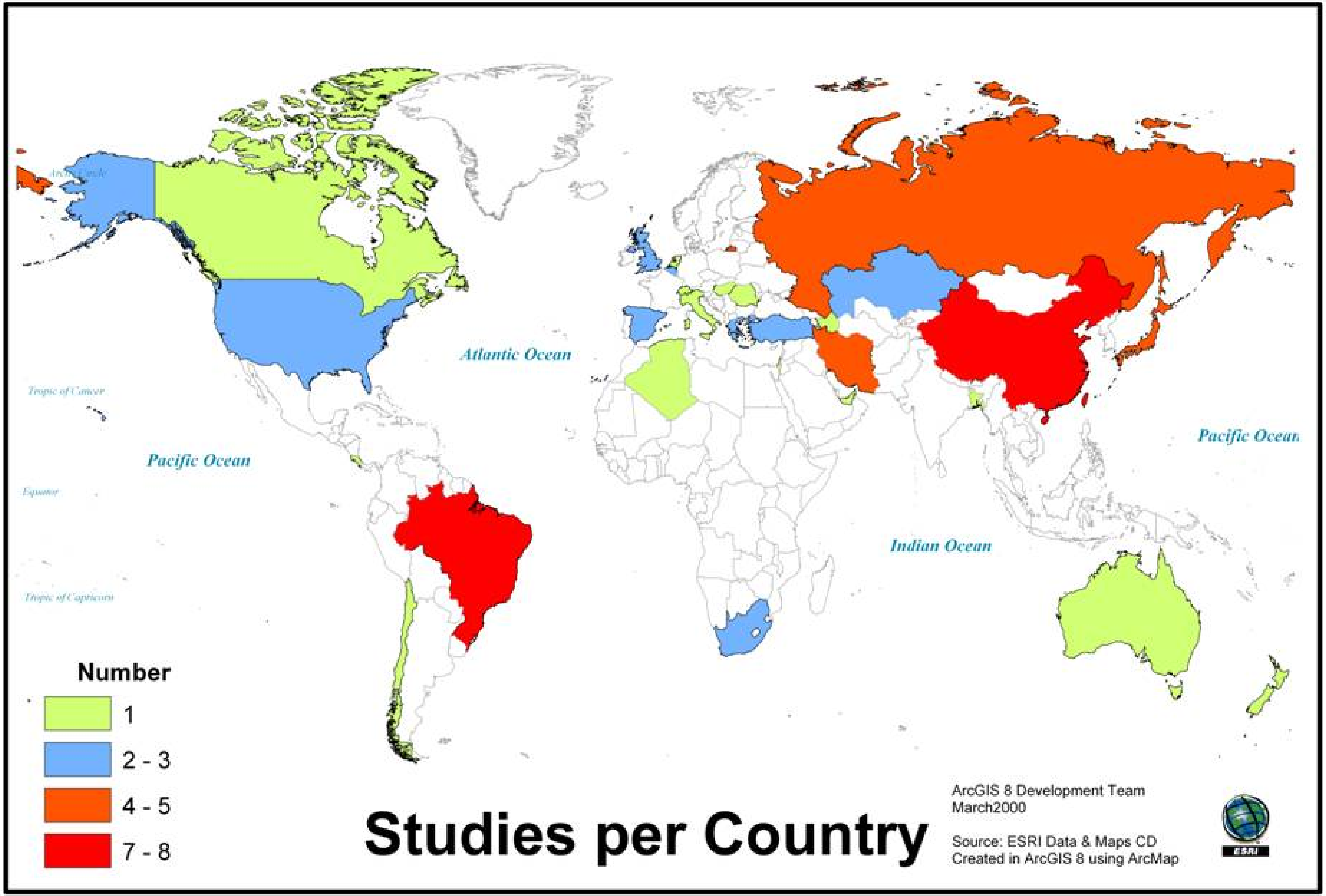
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