Correspondence

https://doi.org/10.1038/s41561-024-01531-0

Urgent need for greater earthquake resilience in continental Asia

When viewed globally, earthquakes hit hard within Asia, with many large death-toll events located along the Alpine–Himalayan mountain belts[1]. Devastating events in 2023 highlight the geographic unevenness in impact on human life, from the Türkiye–Syria earthquakes ("1" in Fig. 1) with over 50,000 deaths, to the Herat (Afghanistan) sequence ("2" in Fig. 1), where 90% of the more than 1,000 casualties were women and children simply because of the time of day when the mainshock struck. We stress the urgent need for new geoscience-led approaches to the continent-wide problem of increasing vulnerability to earthquakes resulting from urbanization.

Time and time again we see earthquakes strike densely populated areas (Fig. 1), a correlation that is not coincidental in continental Asia. Many population centres in this region owe their existence to the presence of active faults that shape the landscape and channel water, creating habitable areas in a region with harsh conditions[2] that are likely to worsen with climate change. The environmental pressures exacerbate the challenges: urban areas and infrastructure projects across the region are expanding rapidly in zones of unknown or unquantified earthquake hazard.

Warnings are sometimes found in recent history, such as the 1948 earthquake that decimated Aşgabat, Turkmenistan[3] ("3" in Fig. 1). Elsewhere, there is need to go further back to demonstrate seismic hazard potential[4,5], for instance to the earthquake in Xi'an (China) ("4" in Fig. 1) in 1556, which killed 830,000 people, a death toll that remains the largest recorded[6]. It is not a matter of if, but when these cities will once again be hit. Many such cities have undergone rapid growth in recent decades and thus have much greater exposure. Almaty in Kazakhstan ("5" in Fig. 1), for example, was badly damaged by earthquakes in 1887, 1889 and 1911 (ref. 7). In early 2024, after over a century of seismic quiescence, two strongly felt events shook a city now home to 2 million people. This nature of earthquake disasters – centuries of calm being punctuated by instants of devastation – adds to the difficulty of mitigating their effects; memories rapidly fade and attention quickly diverts elsewhere.

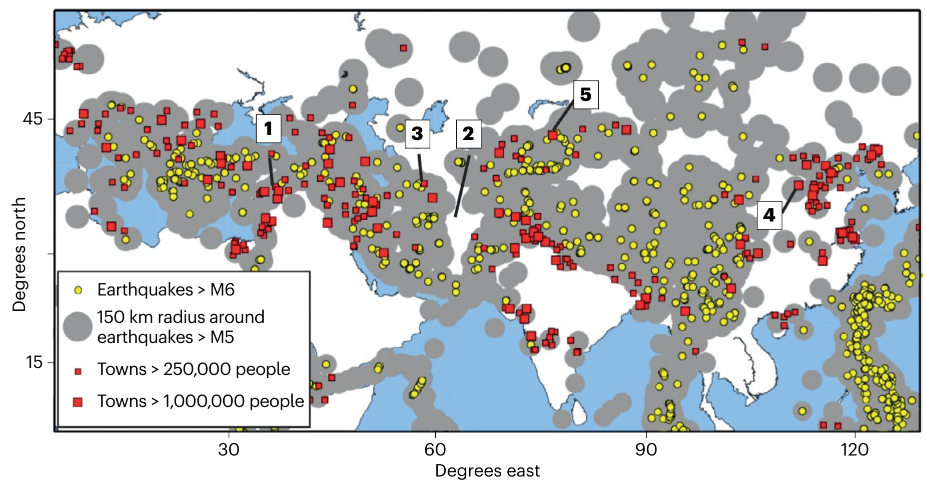

Fig. 1 | Earthquake hazard and population within Asia. The majority of major population sites lie in zones of earthquake hazard, expressed as within 150 km of instrumentally recorded shallow earthquakes with moment magnitude (M_w) less than 5. Basemap created using Generic Mapping Tools[10], with earthquakes from the ISC-EHB Bulletin, hosted by the International Seismological Centre (https://www.isc.ac.uk/isc-ehb/).

The distributed nature of active faulting within continental interiors, with long recurrence intervals along individual faults[1,2], means there is often seismic hazard even in ancient settlements with no documented history of earthquakes. The telltale landscape signatures of active faulting, however, are usually present, but they can be concealed by human landscape modification. It is therefore important to draw together geological and historical data, as well as regional distributions of strain-rates and seismological catalogues to understand the distribution of hazards, and to work quickly whilst the full range of geological evidence remains.

Geoscientists cannot delay. We must ensure that future construction occurs with an up-to-date knowledge of the hazards, and that existing buildings are strengthened effectively. In Almaty, the heritage buildings, Soviet-era apartment blocks, modern high-rises and suburban sprawl present a complex challenge for seismic risk mitigation that is common in cities across the continent. Understanding earthquake hazards, which are also complex in time and space, requires detailed investigation. For example, landscape analysis around Almaty suggests the presence of previously unknown active faults that could cause distinctly different distributions of shaking and substantially more loss and damage than scenarios based upon the historical examples alone[7,8].

The pathway to earthquake resilience in continental Asia is achievable, and naturally collaborative. The geosciences have key roles, from unravelling the complex distribution of active faults and the earthquake histories upon them, to continental-scale measurements of strain accumulation and release as discerned through remote sensing and seismology. A necessary first step is to determine where the hazards lie, which is the foundation on which effective risk assessment and mitigation can be built. The most efficient and equitable method to develop this knowledge is through international partnerships that support and strengthen capacity within the responsible national agencies and academic communities. Education and public awareness efforts are necessary steps towards mitigation[9], as is a long-term view and sustained support from policymakers. Geoscientists can help maintain attention on the problem by continuing study of the hazards and emphasizing the risks that they pose. As recent disasters highlight, it is important that we start now before a long-term future of vulnerability is set, quite literally, in concrete.

Kanatbek Abdrakhmatov[1], **Ramon Arrowsmith**[2], **John Elliott**[3], **Christoph Grutzner**[4], **Aidyn Mukambayev**[5], **Magali Rizza**[6], **Zakeria Shnizai**[7], **Richard Walker**[7] ✉, **Ray Weldon**[8] **& Roberta Wilkinson**[7]

[1]Institute of Seismology, National Academy of Sciences, Bishkek, Kyrgyz Republic. [2]School of Earth and Space Sciences, Arizona State University, Tempe, AZ, USA. [3]COMET, School of Earth and Environment, University of Leeds, Leeds, UK. [4]Institute of Geological Sciences, Friedrich Schiller University Jena, Jena, Germany. [5]National Nuclear Center of the Republic of Kazakhstan, Kurchatov, Kazakhstan. [6]Département des sciences de la Terre et de l'atmosphère, UQAM, Montréal, Canada. [7]COMET, Department of Earth Sciences, Oxford University, Oxford, UK. [8]Earth Sciences Department, University of Oregon, Eugene, OR, USA.

✉e-mail: richard.walker@earth.ox.ac.uk

Published online: 10 September 2024

References

1. England, P. & Jackson, J. *Nat. Geosci.* **4**, 348–349 (2011).
2. Jackson, J. *Philos. Trans. R. Soc. A.* **364**, 1911–1925 (2006).
3. Marshall, N. et al. *Geophys. J. Int.* **237**, 315–338 (2024).
4. Shnizai, Z., Walker, R. & Tsutsumi, H. *J. Asian Earth Sci.* **259**, 105925 (2024).
5. Talebian, M. et al. *Geophys. J. Int.* **207**, 1688–1699 (2016).
6. Feng, X. et al. *J. Geophys. Res. Solid Earth* **125**, e2019JB017848 (2020).
7. Grützner, C. et al. *Tectonics* **36**, 2192–2226 (2017).
8. Amey, R. M. J. et al. *Earth Space Sci.* **8**, e2021EA001664 (2021).
9. Karasözen, E., Büyükakpınar, P., Ertuncay, D., Havazlı, E. & Oral, E. *Seismica* https://doi.org/10.26443/seismica.v2i3.1012 (2023).
10. Wessel, P. et al. *Geochem. Geophys. Geosyst.* **20**, 5556–5564 (2019).

Acknowledgements

The authors thank UKRI (NE/ J02001X/1; NE/ S013911/1; (GA/13/M/031), the Leverhulme Trust (RPG-2018-371), NATO SPS (MYP G5690), and the Royal Society (CHG\R1\170038) for their support of our long-term collaborative programmes researching earthquake hazards in the Tien Shan region, and more widely across Asia.

Competing interests

The authors declare no competing interests.