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Emerging Risks Report 2017

Natural Environment

Seismic Shock
A hazard overview for the Middle East

CatRisk Solutions
Catastrophe Risk Management Technology

oasis LOSS MODELLING FRAMEWORK

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Executive summary

A region on the up

The Middle East is a rapidly urbanising region and a growing business hub.

Of the 398 million people spread across the region, 56% live in cities. This figure is expected to rise to 68% by 2025.

The area attracts large-scale investment, with six of the largest projects in the United Arab Emirates and Saudi Arabia worth more than US$55 billion. Abu Dhabi is spending US$37 billion on various infrastructure projects up to 2020, including completion a new airport terminal and nuclear power plants.

While these demographic and economic changes are driving growth in the region, they are also concentrating high-value assets and populations in a relatively small area.

This means businesses and communities are becoming more vulnerable to natural hazards such as droughts, floods, storms and earthquakes.

The need for earthquake models

The Middle East has a history of earthquake activity. Between 1900 and 2014, the region has been affected by 200 moderate to large earthquakes. These have killed almost 250,000 people and affected 10 million others.

Today, almost a fifth of the population (about 30 million people) in the countries covered by the model in this report is at risk from earthquakes.

The Lloyd’s City Risk Index estimates that US$85 billion of potential economic output of the region’s 22 leading cities could be at risk from earthquakes over the next decade.

These serious consequences of earthquake damage make it important to understand earthquake risk in the region better. To do this, insurers need more earthquake models as there are relatively few that cover the Middle East (Israel, Turkey and Cyprus are the exception). Insurers use risk models to make reliable assessments of the severity and frequency of catastrophe risk. This, in turn, helps them create and price catastrophe insurance products.

A new model for the Middle East

The new model described in this report, developed by CATRisk Solutions in partnership with the Lloyd’s market, helps fill this gap in Middle East earthquake modelling.

It covers earthquake risk in the following countries: Bahrain, Iraq, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, United Arab Emirates and Yemen.

The model has a number of innovative features that distinguish it from other earthquake models for the region.

- It is based on a bespoke seismotectonic source model that generates thousands of simulated earthquake events for the Middle East, on a site-by-site basis. This gives a more detailed view of earthquake risk in the region than existing models.
- The model covers the entire Middle East region as it includes data from all earthquakes that have occurred there since 400BC. This is an important and unique feature of this model as earthquake damage can be caused by tremors that lie outside a modelled country.
- It includes damage metrics that can produce estimates for each simulated earthquake event in the 10,000-year catalogue the model is based on, allowing insurers to assess potential losses on a site-by-site basis, and across their entire portfolio. Not all other models on the market take damage distributions into account in this way.
- It applies a unique probabilistic approach to hazard uncertainty that allows insurers to see the aggregation of losses in all the countries covered by the model. Other models are designed to give country-specific views only.
- The model is based on the latest information on past seismicity, regional tectonic deformation, location and activity of active faults and, where available, slip rate measured from recent GPS surveys.

The model includes data from all earthquakes that have occurred in the wider Middle East region, and further countries may be added as the model develops and further scientific hazard assessments are made available.

Next steps

There are several ways in which this model and the new approach to building it could be developed further:

- Better quality exposure data from future scientific studies could be added to give a fuller picture of earthquake risk and where it would impact the region - the model's modular design means it can be updated as new scientific information becomes available.
- A better understanding of where damage could occur and the resultant losses could be gained by adding more infrastructure vulnerability metrics.
- The unique approach used by this model could be applied to model design for other earthquake-related hazards, such as tsunamis and landslides. This would allow insurers to gain a more complete picture of the risks posed by earthquake-related hazards.
- New models for perils such as wind and flood could be created using the approach used to design this model. This could create a detailed assessment of other potential threats in the region.
- It is anticipated that this model could encourage further collection of more detailed and reliable exposure data in the region.

Conclusion

For insurance to play its full potential in mitigating and transferring earthquake risk in the Middle East, insurers need better earthquake models for the region.

The model described in this report uses the latest data and new modelling techniques to provide a much-needed, additional earthquake model for the region that is different from others on the market.

This model helps insurers gain a deeper understanding of earthquake risk in the Middle East. It could help them design earthquake insurance products that are specific to the region and provides them with a greater understanding of the exposure risk across their portfolios.

Oasis: an alternative way to buy risk models

This new Middle East Earthquake model is available on the Oasis platform, which is supported by Lloyd's. The Oasis platform offers insurers a new, lower cost way of accessing risk models on a 'shared-services' basis. This means they can access a greater choice of models in multiple regions, making it much simpler for them to obtain multiple views of a single risk. This reduces insurers' dependency on just one or two models, meaning they can form a deeper understanding of risks and their impacts around the world. They can then use this information to fine-tune and more accurately price insurance products. See www.oasislmf.org for more information.

Seismic hazard

From 1900- 2014, countries in the Middle East have been affected by approximately 200 moderate-to-large earthquakes, which have resulted in the deaths of about 240,000 people, and affected nearly 10 million others (Guha-Sapir, Below and Hoyois, 2017).

The majority of earthquakes posing seismic hazard to the countries in the Middle East are concentrated along the following six major active belts illustrated in Figure 1 (*overleaf*).

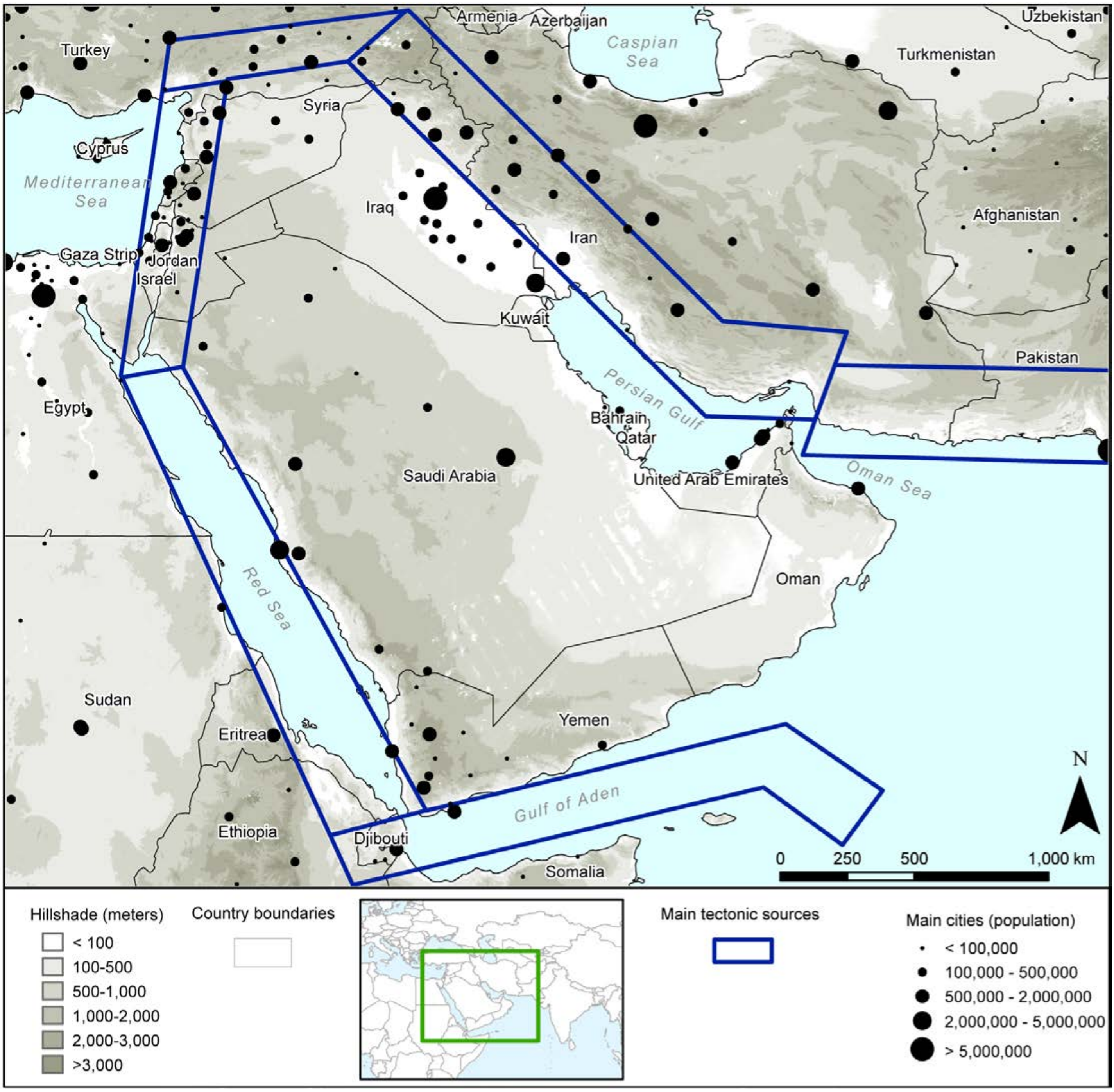
- **The Makran subduction zone:** Countries along the Persian Gulf and Oman Sea are exposed to mega-thrust earthquakes along the Makran Subduction zone which extends some 600km southeast of Iran and southern Pakistan. This region is characterised by offshore Mw>8[a] tsunamigenic earthquakes, as well as onshore moderate to large events.
- **The Zagros fold belt:** The Zagros mountain belt is a collision zone running for more than 1,500km from Van Lake in Eastern Turkey to Strait of Hormuz in Persian Gulf. This zone is characterised by frequent small-to-moderate earthquakes which account for seismic hazard to several countries in this region in addition to more than one third of Iran's population. Most earthquakes in this zone are associated with buried faults under thick sediments, which explains the lack of fault rupture on the surface despite high seismic activity.
- **Tectonic features of Eastern Turkey and north-western Iran:** The northern boundary of the Arabian Peninsula is characterised by complex tectonic zones. One of the main features in this zone is the East Anatolian fault zone and is capable of producing M>7 earthquakes. In addition to eastern Turkey, countries such as Syria and Lebanon are exposed to seismic activity on this zone.
- **Dead Sea fault zone:** The Dead Sea fault runs from the northern part of Red Sea system to the north for almost 1,100km and forms the main source of seismic activity for countries such as Jordan, Israel, Lebanon and Syria. There have been many historical earthquakes associated with this fault, particularly the northern half of the zone. Historical seismicity and recent GPS measurements along this fault system illustrate the potential for moderate-to-large earthquakes on different segments of this fault.
- **Red Sea region:** Seismic activity along the Red Sea is associated with the separation of Africa from the Arabian Peninsula. Within the historical records, earthquakes have been recorded that have caused damage to population centres in Yemen and Saudi Arabia that have been attributed to this zone. The zone also represents the predominant source of seismic activity experienced in Saudi Arabia.
- **The Gulf of Aden:** To the south of the Arabian Peninsula, rifting apart in a similar way to the Red Sea and running in a more east-west direction, the Gulf of Aden continues the motion that has separated the Arabian Peninsula from Africa. Population centres in southern and south-western Yemen are the ones mostly exposed to seismic activity along these zones.

See Figure 1 *(p7*, which illustrates the locations of major cities in the Middle East with regard to these six main sources of seismic activity. In addition to seismicity associated with these distinct faults and active tectonic boundaries, many cities in the Middle East are also exposed to background and intraplate seismic activity associated with structural zones within the overall Arabian Shield.

[a] The moment magnitude scale can be abbreviated as MMS or written as Mw or M. The scale is used by seismologists to measure earthquake size in terms of the energy released.

Figure 1 (*below*), illustrates the locations of major cities in the Middle East with regard to these six main sources of seismic activity. In addition to seismicity associated to these distinct faults and active tectonic boundaries, many cities in the Middle East are also exposed to background and intraplate seismic activity associated with structural zones within the overall Arabian Shield.

Figure 1: Major cities in the Middle East and their position with regard to main sources of seismic activity.



The black dots indicate the location of major cities by population in the region.

Source: CATRisk Solutions

Table 1 (*below*), presents a summary overview of the key facts for the seismic regions explored in the study:

Table 1: Middle East seismic zones

Seismic Region	Main Type of Seismic Hazard	Countries Exposed	Number of Earthquakes with M≥5 in the last 50 years	Chance of M>8
The Zagros fold belt	– Strong ground motion – Landslide	– Iran – Oman – UAE – Kuwait – Irag – Turkey – Syria	N>400	No
The Makran subduction zone	– Strong ground motion – Tsunami – Landslide – Liquefaction	– Iran – Pakistan – Oman – UAE,	N<5	Yes
Red Sea region and the Gulf of Aden	– Strong ground motion	– Yemen – Saudi Arabia – Israel	N>50	No
Dead Sea Fault zone	– Strong ground motion – Landslide – Liquefaction	– Israel – Palestine – Jordan – Lebanon – Syria – Turkey	N>20	Very small
Tectonic Features of Eastern Turkey and North-Western Iran	– Strong ground motion – Landslide	– Turkey – Iran – Syria – Lebanon	N>50	Very small
Intraplate and background seismicity	– Strong ground motion	– All countries in the Middle East	N>20	No

Content based on current scientific understanding from the sources listed in the study references.

Source: CATRisk Solutions

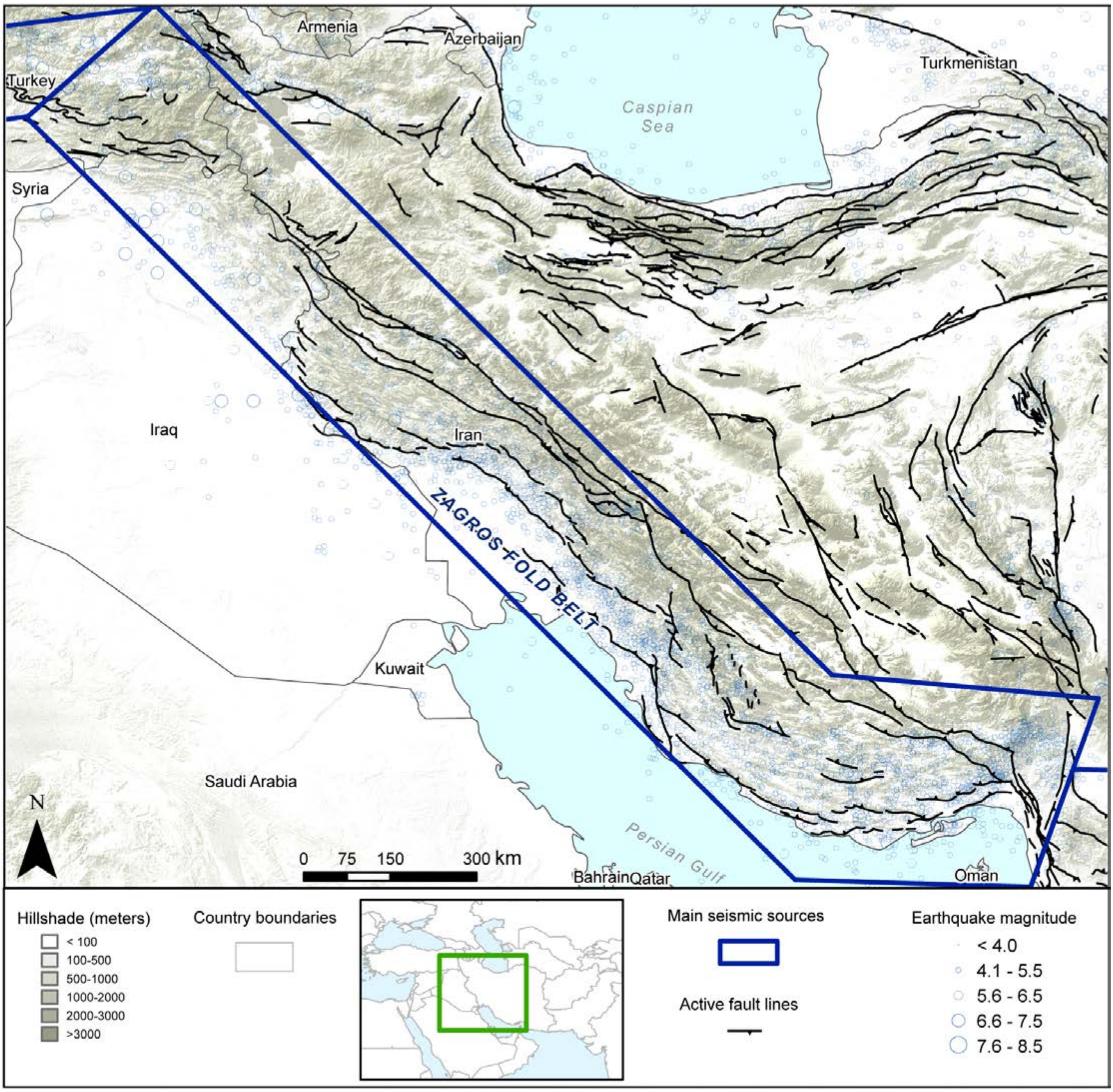
The following sections describe the six seismic regions.

The Zagros fold belt

Summary: Zagros is a major continental collision boundary where buried faults are responsible for moderate to large earthquakes.

The Zagros mountain range is a 200-300km wide continental boundary between the Arabian and Iranian plates *(see Figure 2, below)*. Many Iranian cities, as well as a few cities from other countries in surrounding countries, sit within or in close vicinity to this zone.

Figure 2: The seismicity along the Zagros Folded Belt, showing location and size of historical and recent earthquakes up to 2014



Source: CATRisk Solutions

The Zagros fold belt extends about1,500km in a south-easterly direction from the Turkish border in the north-west, to the Oman Line in the south-east. According to seismicity *(Talebian and Jackson, 2004)* and recent GPS data *(Tatar et al., 2002)* present-day convergence across the Zagros is mainly concentrated in the Simply Folded Zone (SFZ).

This zone is an active belt, with an average shortening of 8–10mm/yr based on a recent GPS survey *(Tatar et al., 2002)* . This shortening accounts for 40–50 per cent of the total present-day about 21mm/yr−1 convergence between Arabia and Eurasia *(Vernant et al., 2004)*.

Seismic activity across the Zagros zone covers a zone about 200km wide that runs parallel to the folded belt. This is indicative of a large number of "reverse basement" faults in the folded parts that can be considered currently active (*See Figure 2, above*).

Most earthquakes in this region occur in the crustal part of the Arabian Plate that underlies the Zagros fold belt. This belt is characterised by a large number of shallow, low to medium magnitude earthquakes, compared to very few large magnitude earthquakes (M_w = 7.0) *(Berberian, 1981)*.

The main sources of future earthquakes in the Zagros are those "buried reverse faults" that are indicated by the development of the surface folds. These faults are hidden by shallow folded sedimentary cover that occurs at such a depth that even large magnitude earthquakes cannot rupture the near surface deposits *(Jackson and McKenzie, 1984; Ni and Barazangi, 1986)*.

Therefore there is no record of large earthquakes in the Zagros. Current scientific understanding is that faults longer than 100km do not exist in the Zagros basement, and therefore there is believed to be a very low probability of occurrence of large magnitude earthquakes (M_w = 8.0) in this region *(Ni and Barazangi, 1986)*.

The seismotectonic map for this region shows traces for the following reverse and strike-slip faults *(Berberian, 1981)*:

- The Main Zagros Reverse Fault
- The Main Recent Fault
- The High Zagros Fault
- The Zagros Mountain Front Fault
- The Zagros Foredeep Fault
- The Zagros-Arabian Boundary Faults
- The Kazerun-Borazjan active strike-slip fault
- The Kareh Bas strike-slip fault
- The Sarvestan strike-slip fault

In areas such as Zagros, where active basement faults are covered by Phanerozoic[b] sedimentary layers, it is difficult to recognise the seismogenic sources for earthquakes. Since the faults responsible for large earthquakes in areas such as the Zagros are difficult to identify, it is difficult to perform fault-specific seismic hazard analysis.

No correlation can be made between the observed seismicity and the tectonic features at the surface. Thus, for the purpose of seismic hazard modelling, it is preferable to consider area seismic sources unless the exact location of active faults are known.

Exposure in several countries such as Iran, Iraq, Kuwait, Qatar, Oman; and Syria could theoretically be affected by seismicity along the Zagros Folded Belt.

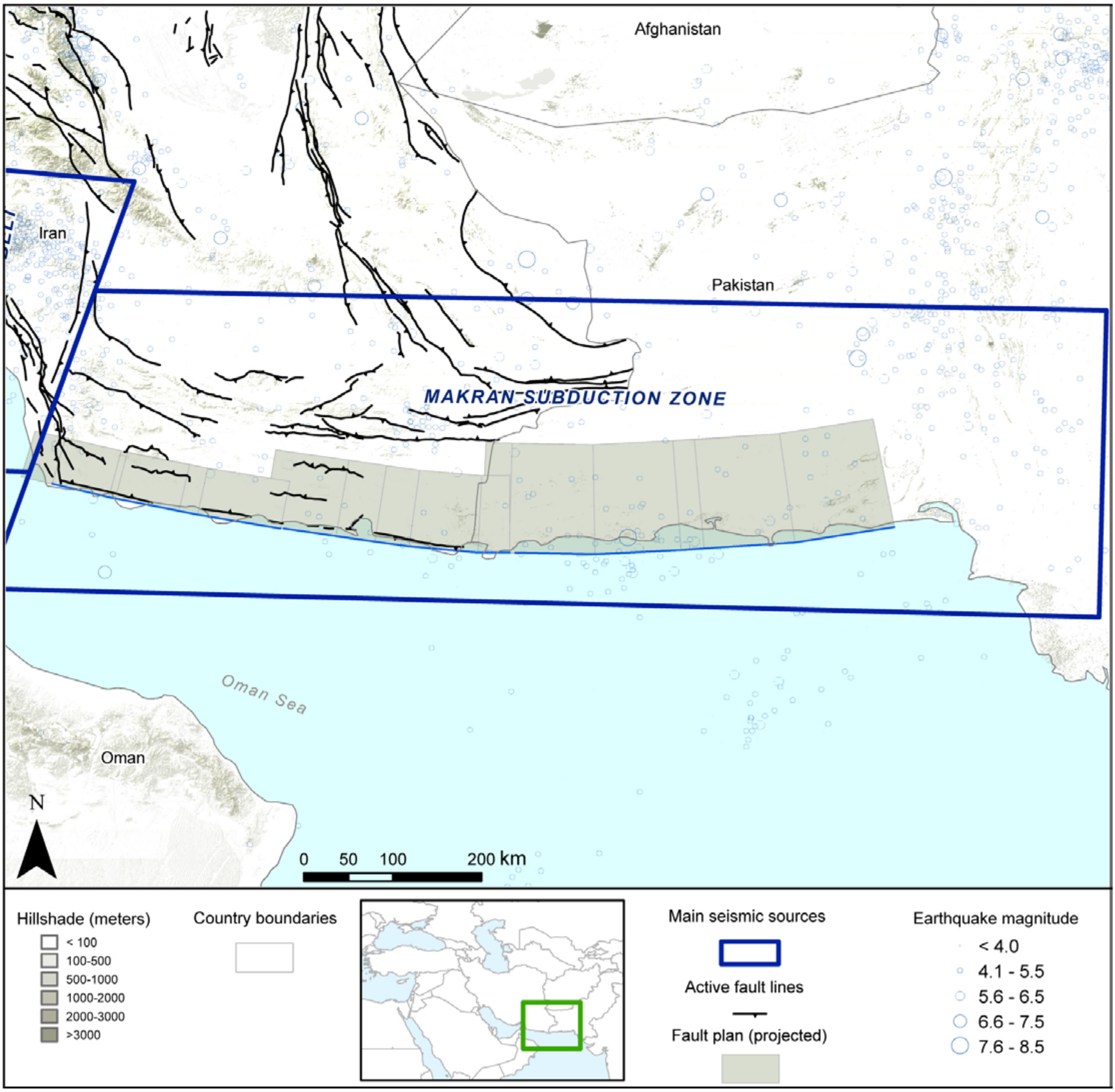
[b] A geologic period that occurred within the last 543 million years – and is considered a time of high biodiversity that generated deep layers of sediment.

The Makran subduction zone

Summary: The Makran region in south eastern Iran is an area where a relatively slow moving subduction is taking place and mega-thrust earthquakes (Mw>8.0) with tsunamigenic potential could happen.

The Zagros folded belt and associated seismicity is truncated east of the Oman Line, where its trace changes from south-east to south-north. The Makran subduction zone sits adjacent to the Zagro fold belt *(illustrated in Figure 3, below)*.

Figure 3: The seismicity along the subduction zone of Makran



Source: CATRisk Solutions

The Oman Line separates two distinct provinces in Iran: the collision zone between the Arabian and Eurasian continents (Zagros folded and thrust belt) on one hand, and an oceanic-continent convergent zone (Makran region) on the other hand *(Kadinsky-Cade and Barazangi, 1982; Barazangi, 1981)*. An active zone of subduction is produced in the Makran region of south Pakistan and southeast Iran where the Arabian Sea floor is subducting at a shallow angle to the north.

The Makran coastal range is an accretionary wedge, where the subduction of the Arabian Sea under the Lut block (southern central Iran plate) and the Helmand (western Pakistan) takes place *(Schlüter et al., 2002)* (*see Figure 3, above)*.

According to Byrne et al. *(Byrne, Sykes and Davis, 1992)*, the rate of convergence between the two plates in Makran is about 40mm/yr. However, recent GPS studies revealed that the subduction rate at Makran is about 19.5mm/yr *(Vernant et al., 2004)*. Comparing this rate to some of the major subduction zones worldwide, Makran is a relatively slow moving subduction zone *(Heidarzadeh et al., 2008)*.

The transition from the collision in the Zagros to subduction in the Makran is marked by a jump from 9±2 mm/yr convergence in the Zagros to ~19±2 mm/yr subduction in Makran *(Heidarzadeh et al., 2008; Masson et al., 2007)*. The Zagros-Makran transition is taking place along Minab-Zendan Fault system which is expected to accommodate a differential motion of at least some 10 mm/yr *(P. Ravaut et al., 1998)*.

Figure 2 (*p10*) and Figure 3 (*p13*) illustrate the recorded evidence that the level of observed seismicity in the Makran relative to Zagros can be considered low. Based on historical records, large to great earthquakes have occurred in the Makran zone; however, the seismicity pattern is completely different in eastern and western Makran.

The most widely known historical tsunami in the region was generated by the Great Makran earthquake on 28 November, 1945. The tsunami occurred off Pakistan's Makran Coast (Balochistan) in the Northern Arabian Sea. The tsunami resulted in the deaths of more than 4,000 people in southern Pakistan, and caused further loss of life and extensive damage along the coasts of western India, Iran, Oman and possibly elsewhere – records continue to be expanded as written sources are uncovered[c].

The occurrence of the Great Makran earthquake of 1945 is a reminder of how subduction zones of apparent low background seismicity may experience great earthquakes *(Laane and Chen, 1989)*. This earthquake was the result of a large thrust along the tectonic plate boundary interface *(Byrne, Sykes and Davis, 1992; Jacob and Quittmeyer, 1979)*.

Based on the catalogue of the large Makran earthquakes, Byrne et al. *(Byrne, Sykes and Davis, 1992)* concluded that the average recurrence cycle of magnitude eight earthquakes – and greater – in Makran is about 100-250 years. Earthquakes with magnitude up to Mw=6.5 occur within the subducted slab at depth of around 60km in western Makran while in eastern Makran, most of the activity occurs along the plate boundary.

The Great Makran earthquake of 1945 was such an event, and in eastern Makran there was an average slip of 6-8m along the plate boundary. The earthquake ruptured a region that covered approximately 75-100km down-dip and 100-150km along the strike *(Byrne, Sykes and Davis, 1992)*.

Exposure in south-eastern Iran, southern Pakistan, Oman and even UAE could experience ground-shaking from earthquakes along the Makran subduction zone. This zone is also capable of generating earthquakes with tsunami potential similar to the 1945 great earthquake.

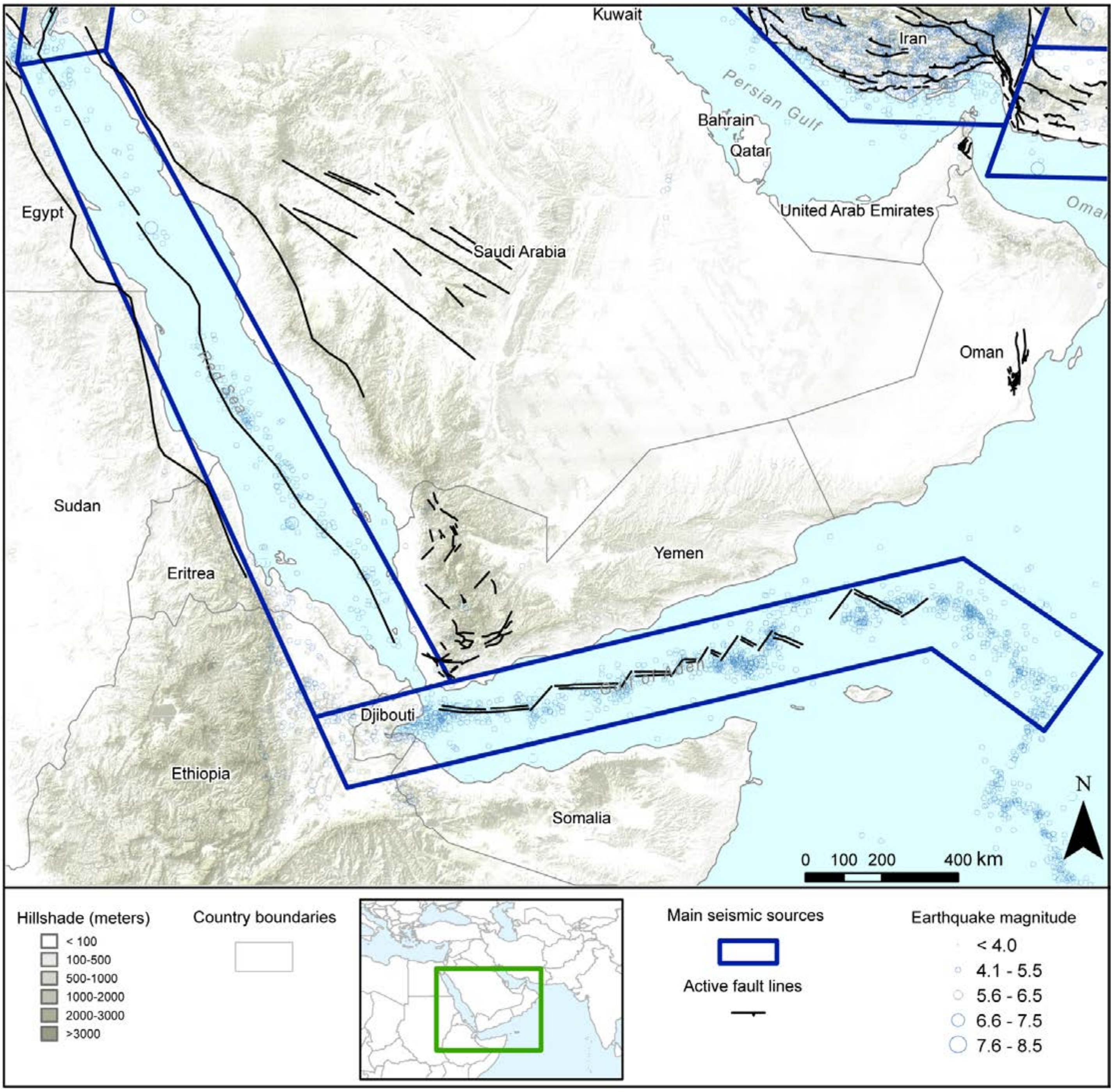
[c] Written evidence, whether anecdotal or from scientific institutions as records are increasing digitised, can be used to expand the historical catalogue. It is also possible to carry out physical assessments of exposed fault lines to construct past earthquakes from features observed in the field.

Red Sea region and the Gulf of Aden

Summary: These regions describe the separation of Arabian Peninsula from African plate in an extensional tectonic movement and where small to moderate off-shore earthquakes happen.

The Red Sea structure (*illustrated in Figure 4, below*) separates Africa from the Arabian Peninsula and is the largest single element of the Afro-Arabian rift system. The Red Sea is directly connected to the Gulf of Aden and the East African rift to the south, whereas to the north the system continues in the Gulf of Suez and the Aqaba-Levant zone the Wadi Araba-Dead Sea transform fault *(Daëron et al., 2005, 2007)*. To the south, the majority of earthquakes and tectonic activity in the Red Sea region is concentrated along a belt that extends from the central Red Sea region south to Afar and then east through the Gulf of Aden.

Figure 4: Seismicity along the Red Sea and Gulf of Aden



Source: CATRisk Solutions

There are historical records indicating that Makkah and surrounding area have been subjected to many earthquakes, mostly from the Red Sea fault at about 150km distance *(Ambraseys, Melville and Adams, 1994)*. Several historical earthquakes that resulted in damages highlight the potential for nearby seismic sources to cause losses. These earthquakes also demonstrate the vulnerability of northern Yemen to moderate-magnitude and larger earthquakes.

The strongest event is believed to be in 1121 A.D which damaged the Yemani corner of Al-Kabba. There is little seismic activity in the northern part of the Red Sea *(Ambraseys, Melville and Adams, 1994)*. The Gulf of Elat is the southern part of the 1,100km long Dead Sea rift structure which includes also the Arava, Dead Sea, Jordan valley, Beq'aa and Orontes segments, extending into the Taurus mountain range (*see Figure 4, above*).

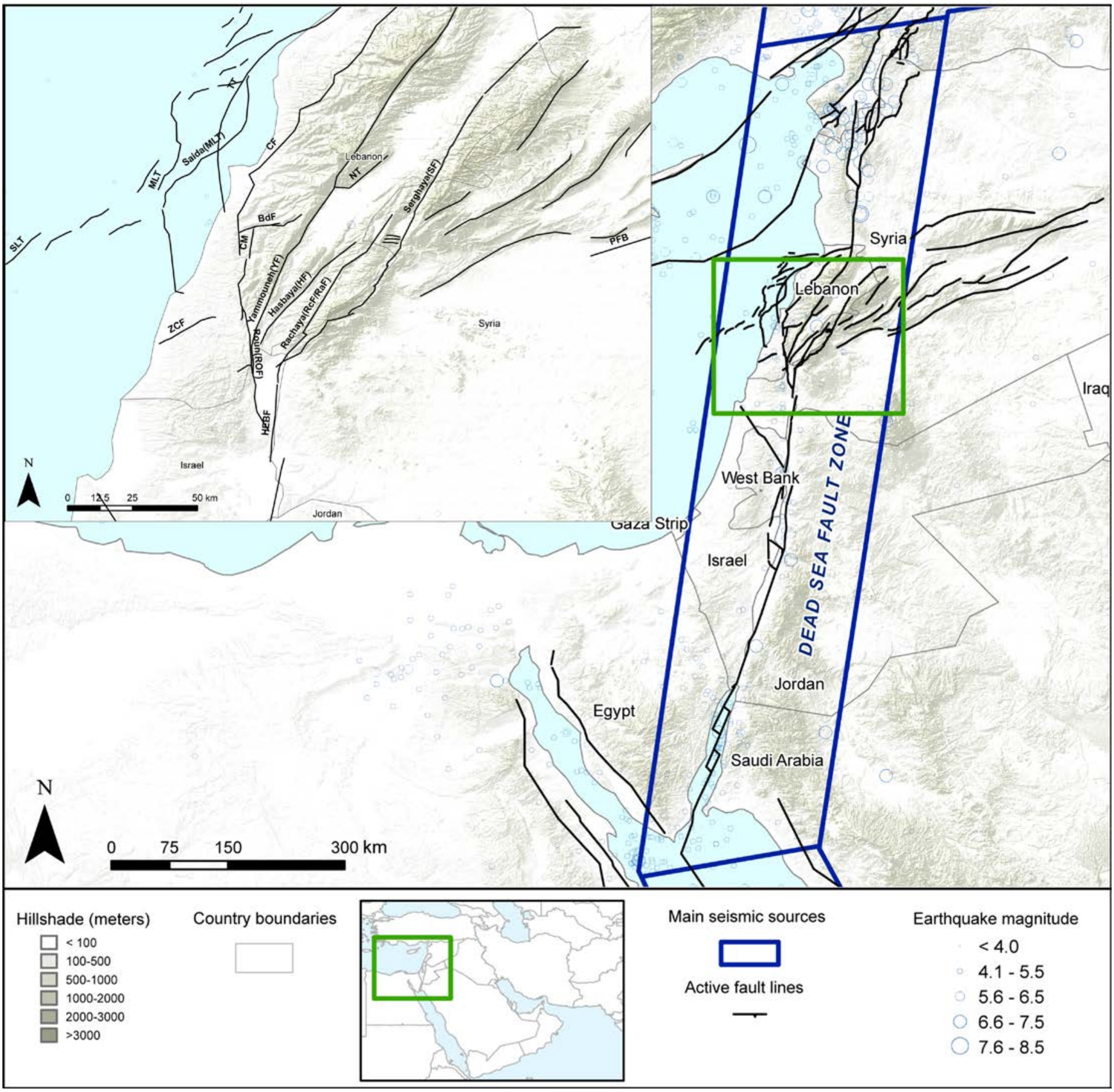
In the Red Sea active rifting is responsible for the geometry of the plate margins in the west and southwest.

Dead Sea Fault Zone

Summary: The left-lateral strike-slip movement along Dead Sea fault system has been responsible for many historical destructive earthquakes and dominant source of seismicity to counties such as Jordan, Lebanon and Israel.

The Dead Sea Fault zone *(illustrated in Figure 5, below*), extends from the northern tip of the Red Sea in a north-easterly direction through the Gulf of Aqabah, Dead Sea, Lebanon, and Syria, and terminates in southern Turkey.

Figure 5: The Dead Sea Transform Fault extending from the Gulf of Aqaba to southeast Turkey



BdF, Beit-ed-Dine fault; CF, Coastal Flexure; CM, Chouf Monocline; OM, Offshore monocline fault.

Source: CATRisk Solutions

The Red Sea rift splits, into two branches to the south of Sinai:

- The Gulf of Suez rift which follows the main trend of the Red Sea
- The Gulf of Elat (Aqaba)- Arava rift, trending N30E to N-S

The Gulf of Elat is the southern part of the 1,100km long Dead Sea rift structure which includes also the Arava, Dead Sea, Jordan valley, Beq'aa and Orontes segments, extending into the Taurus mountain range *(Butler, Spencer and Griffiths, 1997)*.

The Dead Sea transform system is part of the boundary between the African and Arabian plates *(Freund et al., 1970)* connecting active spreading centres of the Red Sea to the area where the Arabian Plate is converging with Eurasia in southern Turkey. The present-day relative motion between Arabian plate and African plate is estimated to be 4-8 mm/yr, based on recent GPS observations *(McClusky et al., 2000, 2003)*.

The left-lateral strike slip Dead Sea Fault takes up the differential motion between the African and the Arabian Plates. These faults are capable of generating large magnitude earthquakes in the region. There are large historical earthquakes associated with the Dead Sea-Jordan rift fault, confirming seismic activity of this system.

The seismicity of the Dead Sea transform is characterised by both swarm and mainshock-aftershock types of earthquake activity. The estimated average shear on the Dead Sea fault is around 5.4mm/yr, based on 110km geological deformation over 20 million years *(Steinitz et al., 1978)*. The instrumental and historical seismic records indicate a seismic slip rate of 0.15-0.35 cm/yr during the past 1,000-1,500 years *(McClusky et al., 2003)*.

Historically, the most significant earthquakes to hit the Gulf of Aqabah area were the events of 1068, 1759, 1822, and 1837, which caused the deaths of more than 30,000 people *(Freund et al., 1970; Ambraseys and Melville, 1982)*. The seismic activity of the Dead Sea-Jordan rift fault can be considered more "complete", with large historical earthquakes and instrumentally recorded seismicity.

Exposure in countries close to the leading edge of these faults such as Syria, Jordan, Lebanon and Israel are exposed to seismic activity from these faults.

Syria has been affected by a sequence of large historical damaging historical earthquakes of 1157, 1170, 1202, 1408, 1759 and 1837 *(Ambraseys and Melville, 1982)*. The Serghaya fault which is a branch of Dead Sea Fault System in the Golan Heights (*see Figure 20, p19*), has been responsible for several destructive earthquakes in the last 2,000 years such as events in 1705 and 1759 *(Ambraseys, 2009)*.

Another active zone in this region is the Palmyride Folding System which is associated to the north-south shortening of Arabian and Eurasian plates with an average velocity of 1.5mm/yr and responsible for several reported historical strong earthquakes *(McClusky et al., 2003)*.

The extension of the Dead Sea Fault into Lebanon splits into five main fault branches: the Roum, Yammouneh, Seghaya, Rachaiya and Hasbaya faults (*see Figure 20, p19*). Yammouneh Fault is the main fault branch of the Dead Sea fault system accommodating most slip of the Dead Sea fault *(Daëron et al., 2005)*. There is debate over the activity of Yammouneh fault although recent paleoseismic investigations have indicated that this fault is tectonically active and had ruptured in infrequent but large earthquakes (*Mw*>7.0) *(Daëron et al., 2005, 2007)*.

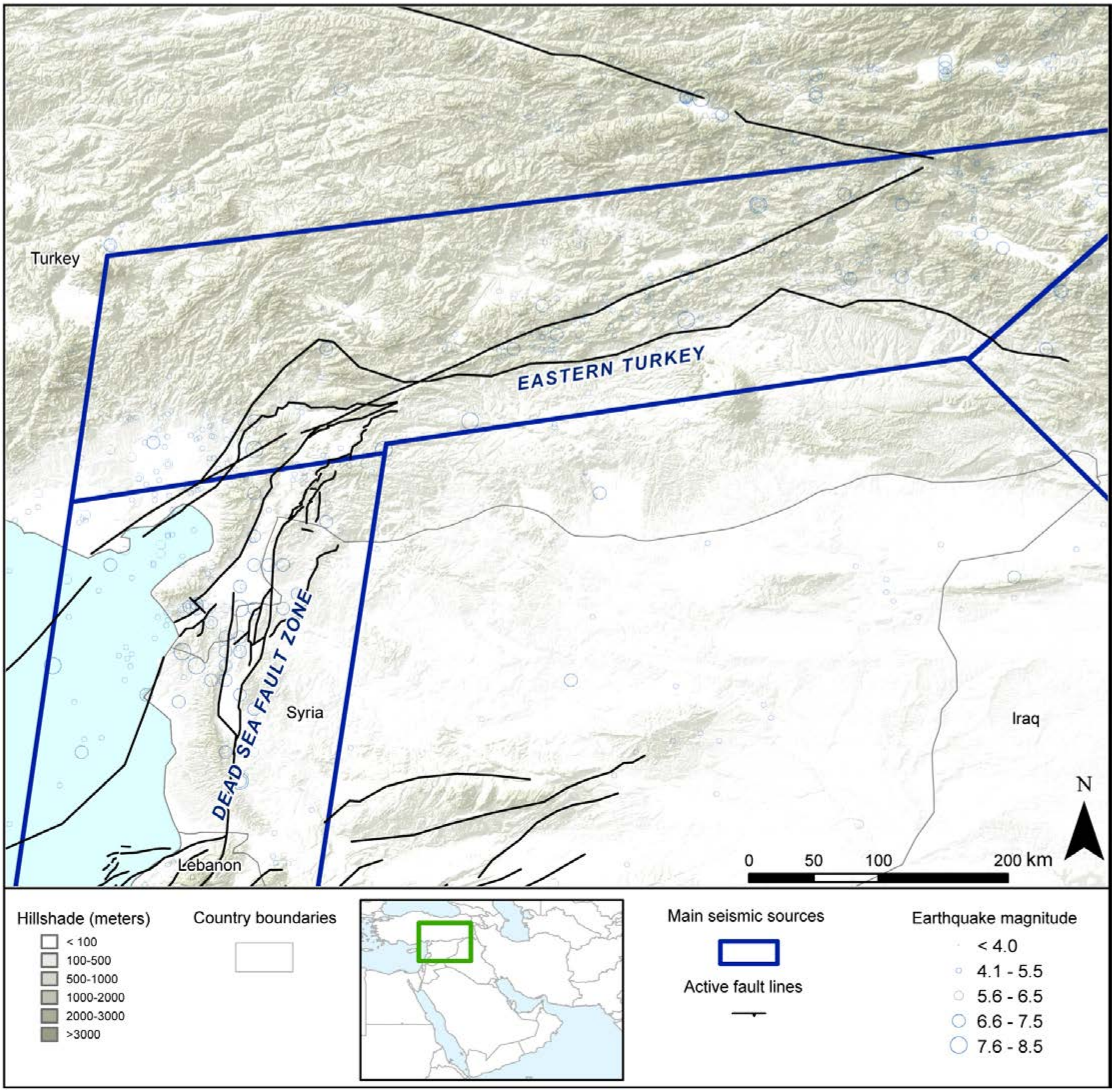
The earthquake swarms in the 1980s and 1990s in the Gulf of Aqabah clearly indicates that this segment is one of the most seismically active zones in the Dead Sea transform system.

Tectonic features of Eastern Turkey and North-Western Iran

Summary: East Anatolian fault system is the dominant source of moderate to large earthquakes in this zone, threatening population centres in Turkey, Iraq and Iran for many centuries.

The seismic activity in eastern Turkey is dominated by the movement of Turkey westwards, along the East and North Anatolian Faults *(Berberian, 1981; Jackson, 1992)*. The East Anatolian Fault Zone is a narrow zone of sinistral transpression that runs from Karlıova in east-central Turkey, where it joins the North Anatolian Fault Zone (*see Figure 6, below*):

Figure 6: Geographical distribution of earthquake epicentres along the East and North Anatolian Faults.



Source: CATRisk Solutions

The African, Arabian and Eurasian plates are interacting in southern Turkey in one of the most complex tectonic zones along the Alpine-Himalayan orogenic belt[d]. The Dead Sea Fault Zone is considered to meet the East Anatolian Fault Zone (EAFZ) at an unstable triple junction sited in southern Turkey. The East Anatolian Fault Zone is a narrow zone plate boundary with seismic activity comparable to that of the North Anatolian Fault; both have been very active historically.

Seismic activity in central Anatolia spreads away from the North and East Anatolian faults, as shown by several historical damaging earthquakes *(Sengör, Burke and Dewey, 1982; Butler, Spencer and Griffiths, 1997)*. Thus the question arises of whether or not central Anatolia can really be considered as a rigid block. The right-lateral strike-slip mechanism continues east of the junction of the North and East Anatolian Faults into Iran (*Figure 6, above*).

This mechanism has been seen in several earthquakes further east, such as the Chaldiran earthquake of 24 November 1976 with observed surface fault *(Toksöz, Nábělek and Arpat, 1978)*, the earthquake of 26 May 1977 at the eastern end of the Chaldiran fault *(Jackson and McKenzie, 1984)*, and the Salmas earthquake of 6 May 1930 *(Tchalenko and Berberian, 1974; Ambraseys and Melville, 1982)*.

[d] An orogenic belt is a regional scale area that has undergone compression from tectonic plate movement, often forming mountains as material "bunches up". The mountain ranges from the Alps to the Himalaya are an example of an orogenic belt.

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