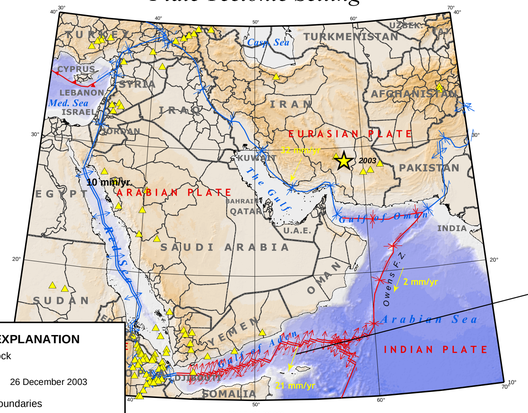
U.S. Department of the Interior
U.S. Geological Survey

General Interest Product xxx

M6.6 Bam, Iran Earthquake of 26 December 2003

Plate Tectonic Setting



EXPLANATION

Main Shock

26 December 2003

Plate Boundaries

- Continental Convergent
- Continental Rifting
- Continental LL Transform
- Continental RL Transform
- Oceanic Convergent
- Oceanic Spreading
- Oceanic LL Transform
- Oceanic Right-Lateral Transform
- Subduction

Volcanoes

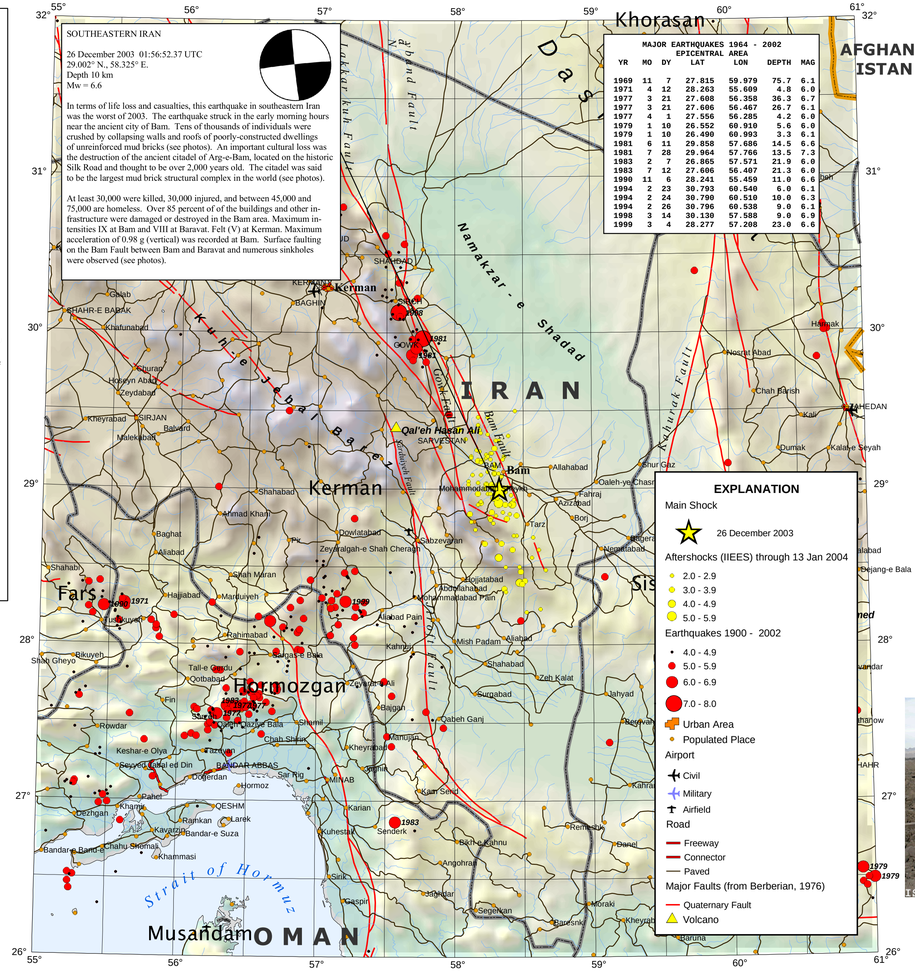
RELATIVE PLATE MOTIONS

The relative motion of adjacent tectonic plates is depicted on the map by short vectors located at selected locations on the plate boundary. In this presentation, one plate is assumed to be rigid and fixed. The vector therefore represents the direction of the moving plate relative to the fixed plate. The rate of relative motion is labelled next to the vector. In this case, the Arabian plate is fixed.

The components of the vector perpendicular and parallel to the plate margin approximate convergent/divergent and transverse direction of motion between the plates,respectively. As viewed from the rigid plate, an inward directed component suggests compression at and near the plate boundary that may be expressed as crustal folding, uplift, thrust faulting, or plate subduction. Similarly, an outward-directed component suggests plate divergence such as would be expected at a zone of crustal spreading. Transcurrent or transform faulting would be expected when the predominantvector component is parallel to the plate margin.

As an example, the relative plate motion vector in Iran along the Zagros Mtns. suggests both compression and right-lateral motion of the Eurasian Plate against the Arabian Plate margin. The rate (32 mm/yr) is relatively high in this area and explains the frequent occurrence of large earthquakes in SW Iran. Conversely, the vector in the Gulf of Aden represents relatively rapid divergence at a rifted spreading zone and nearby transverse motion on short transform fault segments bounding the African Plate. Finally, in the Arabian Sea, the slow (2 mm/yr) rate and nearly parallel relative motion vector against the Indian Plate are consistent with right-lateral displacements along the Owens Fracture Zone where the seismicity is low.

Epicentral Area



SOUTHEASTERN IRAN

26 December 2003 01:56:52.37 UTC
29.002° N., 58.325° E.
Depth 10 km
Mw = 6.6

In terms of life loss and casualties, this earthquake in southeastern Iran was the worst of 2003. The earthquake struck in the early morning hours near the ancient city of Bam. Tens of thousands of individuals were crushed by collapsing walls and roofs of poorly-constructed dwellings of unreinforced mud bricks (see photos). An important cultural loss was the destruction of the ancient citadel of Arg-e-Bam, located on the historic Silk Road and thought to be over 2,000 years old. The citadel was said to be the largest mud brick structural complex in the world (see photos).

At least 30,000 were killed, 30,000 injured, and between 45,000 and 75,000 are homeless. Over 85 percent of of the buildings and other infrastructure were damaged or destroyed in the Bam area. Maximum intensities IX at Bam and VIII at Baravat. Felt (V) at Kerman. Maximum acceleration of 0.98 g (vertical) was recorded at Bam. Surface faulting on the Bam Fault between Bam and Baravat and numerous sinkholes were observed (see photos).

MAJOR EARTHQUAKES 1964 - 2002
EPICENTRAL AREA

YR	MO	DY	LAT	LON	DEPTH	MAG
1969	11	7	27.815	59.979	75.7	6.1
1971	4	12	28.263	55.609	4.8	6.0
1977	3	21	27.608	56.358	36.3	6.7
1977	3	21	27.686	56.467	26.7	6.1
1977	4	1	27.556	56.285	4.2	6.0
1979	1	10	26.552	60.910	5.6	6.0
1979	1	10	26.490	60.993	3.3	6.1
1981	6	11	29.858	57.686	14.5	6.6
1981	7	28	29.964	57.766	13.5	7.3
1983	2	7	26.865	57.571	21.9	6.0
1983	7	12	27.696	56.407	21.3	6.0
1990	11	6	28.241	55.459	11.0	6.6
1994	2	23	30.793	60.540	6.0	6.1
1994	2	24	30.790	60.510	10.0	6.3
1994	2	26	30.796	60.538	9.0	6.1
1998	3	14	30.130	57.588	9.0	6.9
1999	3	4	28.277	57.208	23.0	6.6

EXPLANATION

Main Shock

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Aftershocks (IIEES) through 13 Jan 2004

- 2.0 - 2.9
- 3.0 - 3.9
- 4.0 - 4.9
- 5.0 - 5.9

Earthquakes 1900 - 2002

- 4.0 - 4.9
- 5.0 - 5.9
- 6.0 - 6.9
- 7.0 - 8.0

Urban Area

Populated Place

Airport

- Civil
- Military
- Airfield

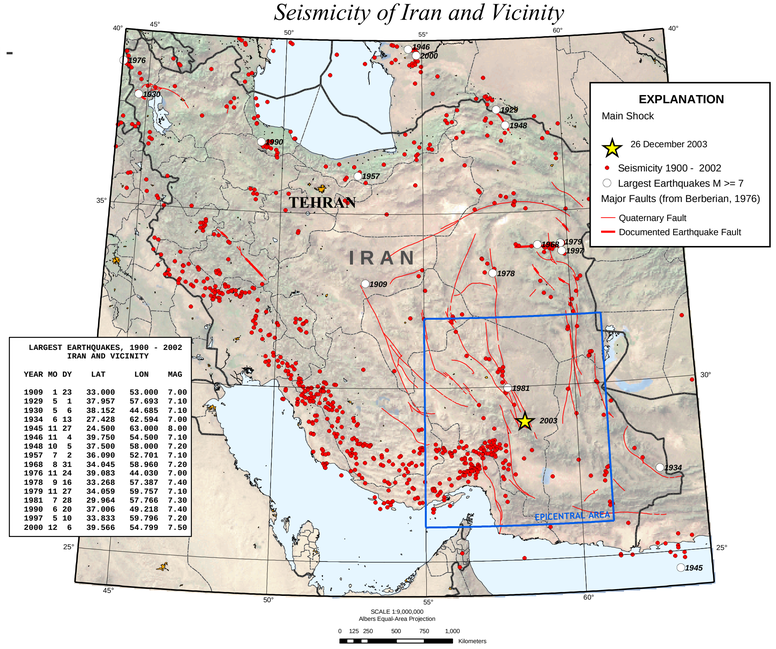
Road

- Freeway
- Connector
- Paved

Major Faults (from Berberian, 1976)

- Quaternary Fault
- Volcano

Seismicity of Iran and Vicinity



EXPLANATION

Main Shock

26 December 2003

Seismicity 1900 - 2002

Largest Earthquakes M >= 7

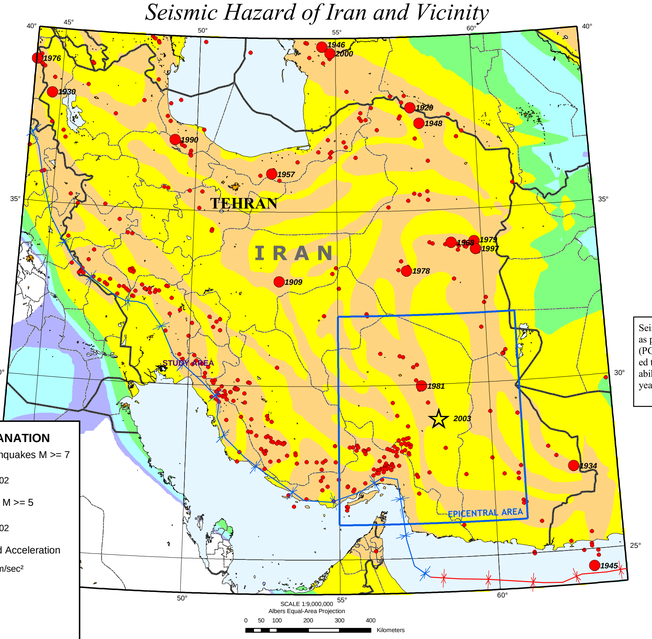
Major Faults (from Berberian, 1976)

- Quaternary Fault
- Documented Earthquake Fault

LARGEST EARTHQUAKES, 1900 - 2002
IRAN AND VICINITY

YEAR	MO	DY	LAT	LON	MAG
1909	1	23	33.000	53.000	7.00
1929	5	1	37.957	57.693	7.10
1930	5	6	38.152	44.685	7.10
1934	6	13	27.428	62.594	7.00
1945	11	27	24.500	63.000	8.00
1946	11	4	39.750	54.500	7.10
1948	10	5	37.500	58.000	7.20
1957	7	2	36.090	52.701	7.10
1968	8	31	34.045	58.960	7.20
1976	11	24	39.083	44.030	7.00
1978	9	16	33.268	57.387	7.40
1979	11	27	34.059	59.757	7.10
1981	7	28	29.964	57.766	7.30
1990	6	20	37.006	49.218	7.40
1997	5	10	33.833	59.796	7.20
2000	12	6	39.566	54.799	7.50

Seismic Hazard of Iran and Vicinity



EXPLANATION

Largest Earthquakes M >= 7

- 1900 - 2002

Earthquakes M >= 5

- 1900 - 2002

Peak Ground Acceleration

- 0.0 - 0.2 m/sec²
- 0.2 - 0.4
- 0.4 - 0.8
- 0.8 - 1.6
- 1.6 - 3.2
- 3.2 - 6.4

Seismic hazard is expressed as peak ground acceleration (PGA) in meters/sec² expected to be exceeded with a probability of 10 percent in a 50-year period

Photo Gallery

Photos from International Institute of Earthquake Engineering and Seismology and World Agency of Planetary Monitoring and Earthquake Risk Reduction

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E.R. Engdahl, Van der Hilst, R.D., and Buland, R.P., 1998, Global teleseismic earthquake relocation with improved travel times and procedures for depth determination, Bull. Seism. Soc. Amer., v. 88, pp. 722-743.

Engdahl, E.R. and Villasenor, A., 2002, Global Seismicity: 1900-1999 in International Earthquake and Engineering Seismology, Part A: v. 81A, ch. 41, 26 p.

DISCUSSION

This earthquake occurred as the result of stresses generated by the motion of the Arabian plate northward against the Eurasian plate at a rate of approximately 3 cm/yr (about one inch per year). Deformation of the Earth's crust in response to the plate motion takes place in a broad zone that spans the entire width of Iran and extends into Turkmenistan. Earthquakes occur as the result of both reverse faulting and strike-slip faulting within the zone of deformation. Preliminary analysis of the pattern of seismic-wave radiation from the December 26 earthquake is consistent with the earthquake having been caused by right-lateral strike-slip motion on a north-south oriented fault. The earthquake occurred in a region within which major north-south, right-lateral, strike-slip faults had been previously mapped, and the epicenter lies near the previously mapped, north-south oriented, Bam fault. Field investigations have tentatively shown that the earthquake occurred on the Bam fault.

The December 26 earthquake is 100 km south of the destructive earthquakes of June 11, 1981 (magnitude 6.6, approximately 3,000 deaths) and July 28, 1981 (magnitude 7.3, approximately 1,500 deaths). These earthquakes were caused by a combination of reverse-motion and strike-slip motion on the north-south oriented Gowk fault.

DISCLAIMER

This map is preliminary and has not been edited for conformity with U.S. Geological Survey standards. Base map data, such as place names and political boundaries, are the best available but may not be current or may contain inaccuracies and therefore should not be regarded as having official significance.

DATA SOURCES

EARTHQUAKES AND SEISMIC HAZARD
USGS, National Earthquake Information Center
NOAA, National Geophysical Data Center
U.S. Agency for International Development
IASPEI, Centennial Catalog (1900 - 1999) and extensions (Engdahl and Villasenor, 2002)
HDF (unpublished earthquake catalog) (Engdahl, 2003)
Global Seismic Hazard Assessment Program
International Institute of Earthquake Engineering and Seismology (IIEES) Research Center, Tehran

PLATE TECTONICS AND FAULTS
PB2003 (Bird, 2003)
Seismotectonics of Iran (Berberian, 1976)

VOLCANOES
Smithsonian Institution, Global Volcano Program

BASE MAP
NIMA and ESRI, Digital Chart of the World
USGS, EROS Data Center

NEWS SOURCES
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IranMania (http://www.iranmainia.com)
The New York Times (http://www.nytimes.com)

ONLINE RESOURCES
http://www.iiees.ac.ir/English/eng_index.html
http://www.gsi-iran.org/

Map prepared by U.S. Geological Survey
National Earthquake Information Center
14 January 2004
Map not approved for release by Director USGS