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Seismotectonic Map of Afghanistan and adjacent areas

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INTRODUCTION

This map is part of a U.S. Geological Survey assessment of Afghanistan's geology, natural resources, and natural hazards. One natural hazard is shaking caused by earthquakes, and one way to evaluate the shaking hazard is the probabilistic seismic-hazard map of Boyd and others (2007). The sources that are incorporated into the hazard map are this seismotectonic map, a comprehensive catalog of the region's earthquakes (Dewey, 2006), and a map and database of faults that offset geologically young landforms (Ruleman and others, 2007).

A seismotectonic map shows geological, seismological, and other information that previously was scattered among many sources. The purpose of combining all the information into a single map is to aid in the design and construction of a seismic-hazard map. This compilation shows spatial relationships that might not be apparent when comparing the original sources. The spatial relationships can suggest hypotheses that might not have occurred to people who studied those scattered sources. For this reason, all of the data on the large, primary map are potentially of equal importance to understanding the processes that cause earthquakes in Afghanistan. Digital data and metadata that characterize the earthquakes and faults are downloadable from the Web pages of the publications cited below. The Web pages are available at http://infotrek.er.usgs.gov/pubs/.

Figure 1 shows the modern plate-tectonic setting of Afghanistan, and Figure 2 summarizes how past plate motions produced the present setting. The primary map shows the faults and earthquakes of Afghanistan. The colored dots that represent the country's abundant earthquakes obscure many of the faults in the northeast. Accordingly, figure 3 shows the northeastern faults without the earthquake symbols.

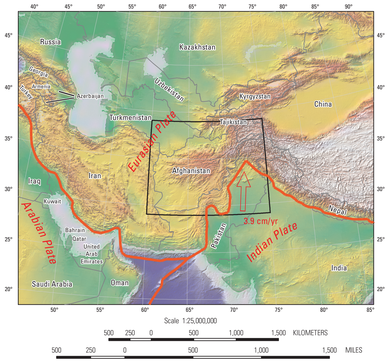

Figure 1. Plate-tectonic setting of Afghanistan and surrounding area. The modern deformation and abundant earthquakes are caused by the collision of the northward moving Indian plate with the Eurasian plate. The plates converge at a rate of about 3.9 cm/yr. Black rectangle shows area of primary map.

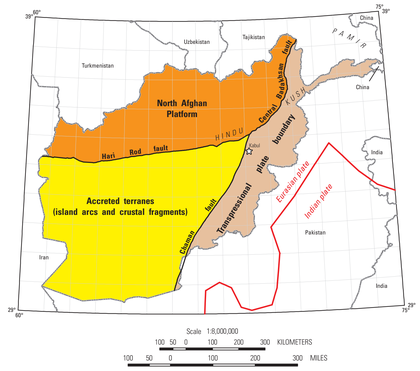

Figure 2. Plate-tectonic evolution of Afghanistan. Map area is the same as for the primary map. Colored areas and large, bold labels identify the three plate-tectonic provinces of Afghanistan (Wheeler and others, 2005; see text). The mountainous Hindu Kush and Pamirs contain large areas that are higher than 3 km, and peaks that are higher than 5 km. The primary map shows hundreds of faults that were formed at various times during the plate-tectonic evolution of Afghanistan.

AFGHANISTAN PLATE TECTONICS

Afghanistan forms a southward-projecting promontory of the Eurasian plate (fig. 1). The North Afghan platform (fig. 2) has been part of the Eurasian plate for 250–350 million years. Additionally, over the past 250 million years, several island arcs and fragments of continental and oceanic crust have colluded with, and been added to, the southerly edges of the platform and are now part of the Eurasian plate (Wheeler and others, 2005).

Today, the east-striking Hari Rud (HR) fault marks the boundary between the North Afghan platform to the north and the accreted arcs and fragments to the south (fig. 2). The most recent of these collisions is with the Indian plate, which is subducting northward under the Eurasian plate at a rate of about 3.9 cm/yr. As the Indian plate moves northward past present-day Afghanistan, the two are separated by a broad, north-northeast trending, transpressional plate boundary that accommodates the movement by left-lateral shear. In southeastern Afghanistan, the western edge of the plate boundary is the long, north-striking Chaman fault (CH). Northeast of Kabul, the Central Badakhshan fault (CB) and similar faults parallel to it on either side form the western edge of the plate boundary.

Subduction of the Indian plate drives the active faults and earthquakes in Afghanistan and other regions to the north, east, and south, resulting in a significant seismic hazard. In contrast, present-day tectonics west of Afghanistan are driven by subduction of the Arabian plate under Eurasia, mainly along the northwest-trending subduction zone that coincides with the Zagros Mountains of coastal Iran.

The primary map shows evidence suggesting that modern subduction of the Indian plate may be creating a system of new faults that cut across the older faults formed during the plate-tectonic construction of Afghanistan (C.A. Ruleman, oral commun., 2005–2006). The older faults are shown as black lines, whereas apparent fault offsets of younger landforms are shown as red lines. Numerous coincidences of red and black lines indicate that the Hari Rud, Chaman, and other faults may be reactivated in the modern stress field. This relationship exists to varying degrees in all parts of the country. In addition, throughout northeastern Afghanistan, the map shows numerous other red lines that trend northwest across the older fault fabric (fig. 3). The straightness and continuity of the northwest-trending red lines across the intensely sheared fault blocks of the transpressional plate boundary suggest that the red lines may delineate a system of new or recently reactivated faults. The straight shapes of most of the red lines across the tall mountains and deep valleys of the Hindu Kush suggest that the northwest-striking faults may dip steeply. Steep dips and northwest strikes would be consistent with strike-slip motion in the ambient stress field.

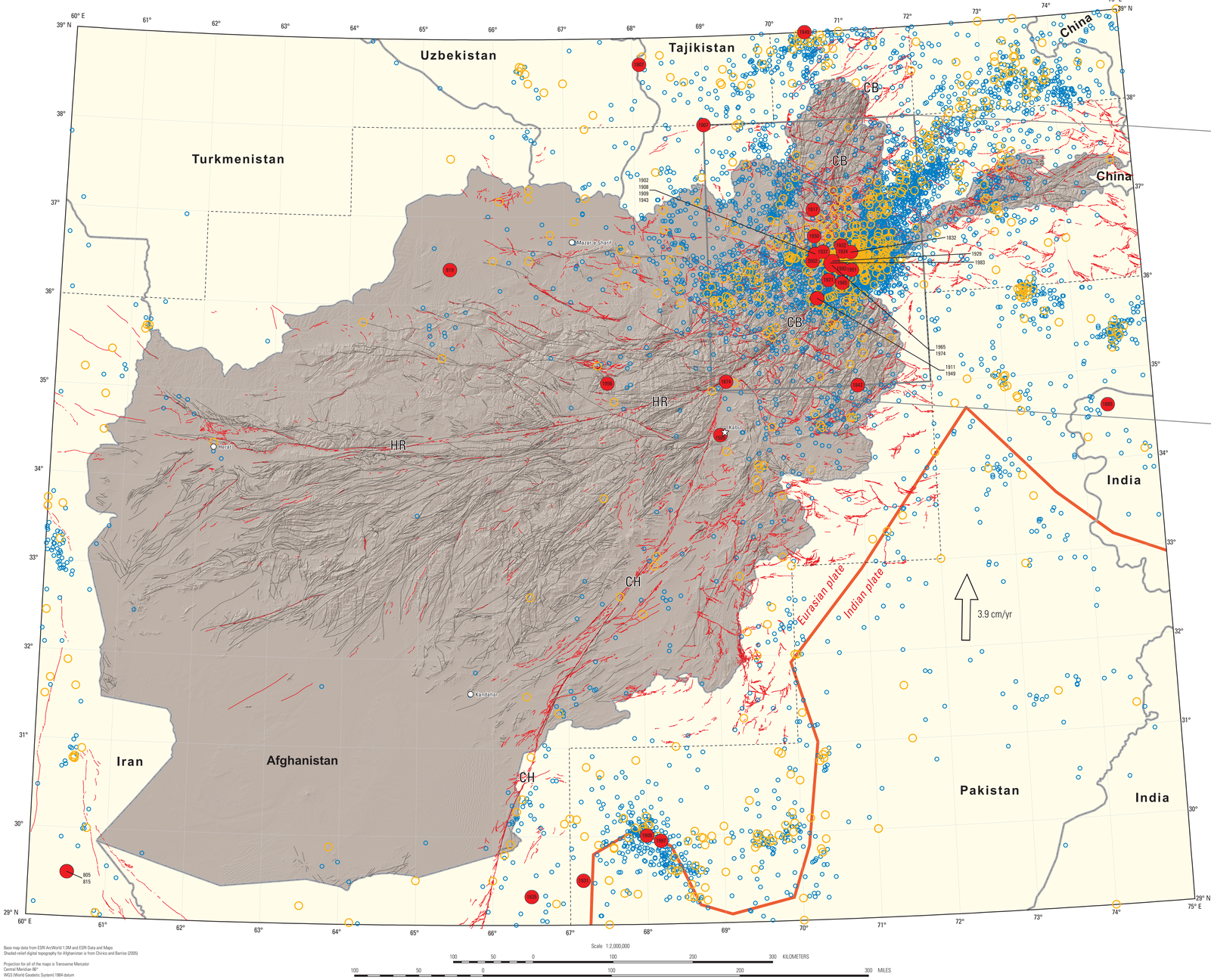

Table 1. Earthquakes of M 7.0 or larger in map area
[Earthquakes are from the catalog of E.A. Bergman (Dewey, 2006), which includes those known to have occurred in the map area between 2000 B.C. and A.D. 2004, inclusive. –, unknown value]

Year (A.D.)	Month	Day	Latitude (N.)	Longitude (E.)	Depth (km)	Magnitude
805	12	2	29.5°	60.5°	-	7.0
815	-	-	29.5°	60.5°	-	7.0
819	6	-	36.4°	65.4°	-	7.4
1505	7	6	34.5°	69.1°	-	7.3
1832	1	22	36.5°	71°	180	7.4
1842	2	19	35°	71°	-	7.5
1874	10	18	35.1°	69.2°	-	7.0
1885	5	30	34.8°	74.38°	-	7.0
1902	10	6	36.5°	70.5°	200	7.2
1907	10	21	38.7°	68.1°	24	7.3
1907	10	21	38°	69°	35	7.2
1908	10	24	36.5°	70.5°	220	7.0
1909	7	7	36.5°	70.5°	230	7.6
1909	10	20	30°	68°	60	7.0
1911	7	4	36°	70.5°	190	7.4
1917	4	21	37°	70.5°	220	7.1
1921	11	15	36.2°	70.67°	135	7.6
1922	12	6	36.58°	70.87°	213.4	7.3
1924	10	13	36.51°	70.89°	187.7	7.2
1929	2	1	36.41°	70.74°	198.3	7.0
1931	8	27	29.5°	67.17°	32.6	7.2
1935	5	30	29.22°	66.5°	10	7.6
1937	11	14	36.52°	70.61°	203.8	7.1
1943	2	28	36.5°	70.5°	210	7.1
1949	3	4	36°	70.5°	230	7.4
1949	7	10	39°	70.5°	16	7.5
1950	7	9	36.7°	70.5°	223	7.5
1951	6	12	36.2°	71°	223	7.5
1956	6	9	35.11°	67.57°	27.4	7.5
1965	3	14	36.37°	70.72°	214.4	7.5
1974	7	30	36.36°	70.73°	214.7	7.1
1983	12	30	36.39°	70.71°	214.5	7.4
1985	7	29	36.16°	70.86°	100	7.4
1993	8	9	36.22°	70.86°	215	7.0
1997	2	27	29.94°	68.18°	22	7.1
2002	3	3	36.42°	70.46°	204	7.4

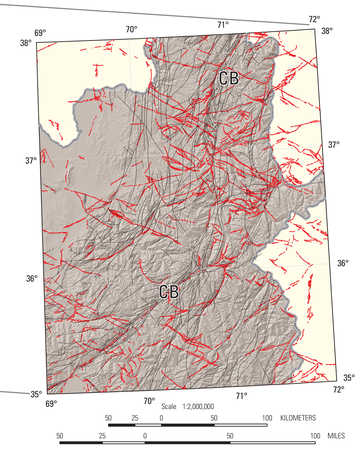

Figure 3. Map showing complex network of faults in northeastern Afghanistan. Map duplicates the part of the primary map that is outlined in dark gray, except that dots showing earthquake locations are removed to reveal the fault pattern. Note the oblique orientation of many of the inferred younger faults shown in red with respect to the pattern of older faults shown in black. CB is the location of the Central Badakhshan fault.

Explanation

M ≥ 7	Locations of earthquakes from 2000 B.C. to A.D. 2004 throughout the map area. Dots are sized and colored according to earthquake magnitude (M). Years of earthquakes with M ≥ 7 are placed within the red dot. From Dewey (2006)
5 ≤ M < 7	
M < 5	
	Selected geologic faults (Doebrich and Wahl, 2006) within Afghanistan as mapped by Afghan and Russian geologists
	Part of possible fault expressed in young deposits and on the landscape, as interpreted from high-resolution satellite images. From Ruleman and others (2007). Coverage includes only areas in and close to Afghanistan
	Boundary of study area for Ruleman and others (2007)
	Northward velocity of Indian plate relative to Eurasian plate. From Wheeler and others (2005)
CH HR CB	Locations of Chaman fault (CH), Hari Rud fault (HR), and Central Badakhshan fault (CB)
	Generalized southeastern edge of boundary between Indian and Eurasian plates. See "Afghanistan plate tectonics". From Dewey (2006) and section 3.1 of Wheeler and others (2005)

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