Seismic Zones of the Arabian peninsula

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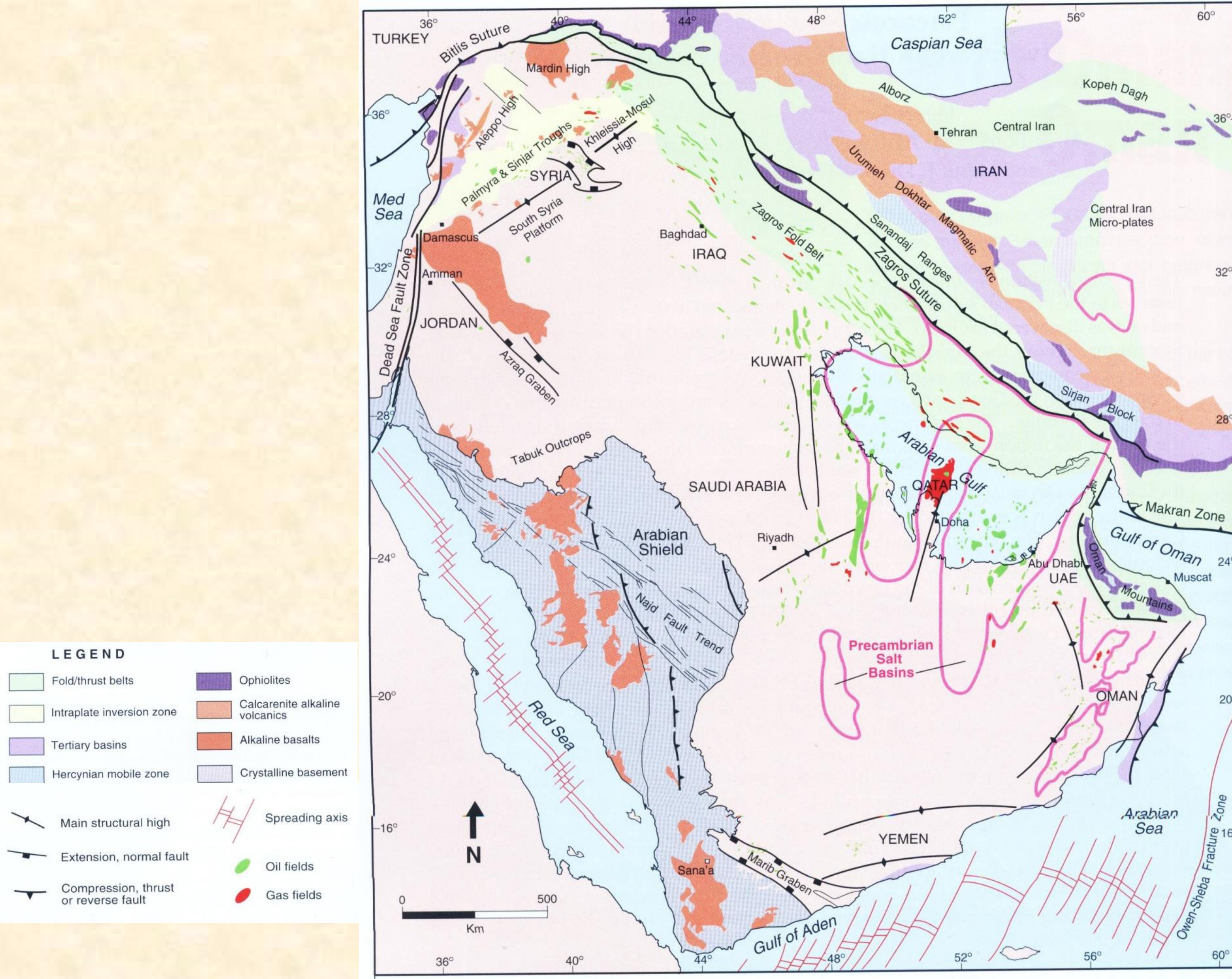
ARABIAN PLATE BOUNDARIES

1. **ACTIVE SEA-FLOOR SPREADIG:** Along the axial troughs of the Red Sea and Gulf of Aden.
2. **DEAD SEA FAULT SYSTEM:** Predominantly left lateral transform fault which defines the NW boundary of the Arabian plate.
3. **TAURUS-ZAGROS THRUST BELT:** As result of continental collision associated with the NE boundary between the Arabian plate and the Persian and Turkish plates.
4. **MAKRAN BELT**: In the Gulf of OMAN. The Arabian plate is subducting beneath the Makran region of Pakistan and Iran, Thus marking the Eastern plate boundary.
5. **THE OWEN FRACTURE ZONE:** Relativity active transform fault forms the SE boundary of the plate.


LEGEND
Fold/thrust belts
Intraplate inversion zone
Tertiary basins
Hercynian mobile zone
Ophiolites
Calcarenite alkaline volcanics
Alkaline basalts
Crystalline basement
Main structural high
Extension, normal fault
Compression, thrust or reverse fault
Spreading axis
Oil fields
Gas fields
TURKEY
Bitlis Suture
Mardin High
Caspian Sea
Alborz
Kopeh Dagh
Tehran
Central Iran
IRAN
Aleppo High
Khleissia-Mosul High
Palmyra & Sinjar Troughs
SYRIA
Med Sea
South Syria Platform
Damascus
Amman
JORDAN
Dead Sea Fault Zone
Azraq Graben
Baghdad
IRAQ
Zagros Fold Belt
Zagros Suture
Sanandaj Ranges
Urumieh Dokhtar Magmatic Arc
Central Iran Micro-plates
KUWAIT
Sirjan Block
Arabian Gulf
Tabuk Outcrops
SAUDI ARABIA
QATAR
Doha
Makran Zone
Gulf of Oman
Arabian Shield
Riyadh
Abu Dhabi
UAE
Oman Mountains
Muscat
Najd Fault Trend
Precambrian Salt Basins
OMAN
Red Sea
Arabian Sea
Owen-Sheba Fracture Zone
YEMEN
Sana'a
Marib Graben
Gulf of Aden
N
0
500
Km
36°
40°
44°
48°
52°
56°
60°
16°
20°
24°
28°
32°
36°

The “Najd Rift System” consists of :

1. Najd Fault System
2. Oman Rift
3. Punjab Rift
4. Dibba Rift
5. Zagros Fault
6. Sinai Triple Junction

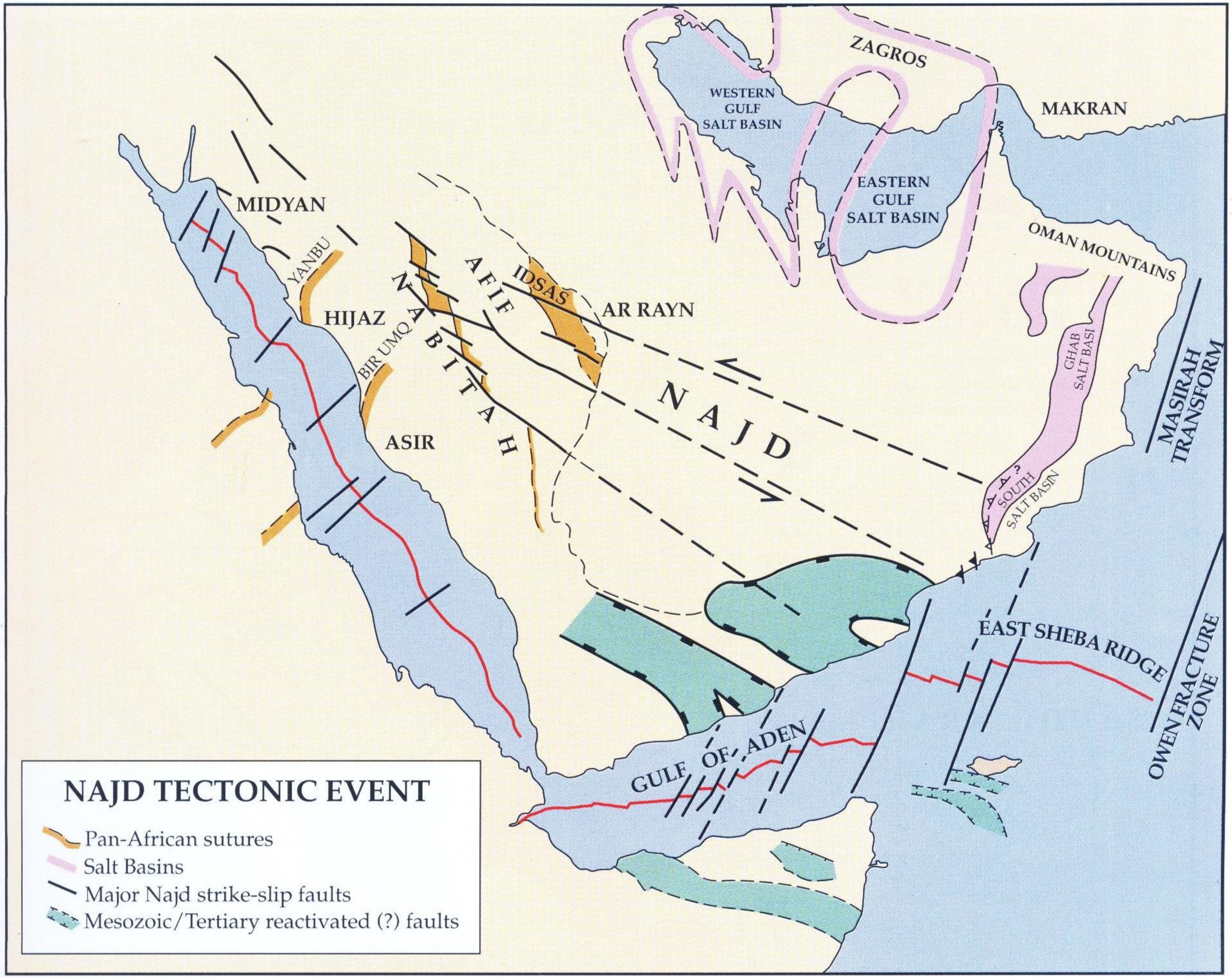


Figure 1: The Arabian Peninsula, with Precambrian terranes in the Arabian Shield area of western Saudi Arabia and the Infra-Cambrian sinistral Najd tectonic event (600-530 Ma) (Brown and Jackson, 1960; Moore, 1979) with its Mesozoic and Tertiary reactivations (Bott et al., 1992; Richardson et al., 1995). Microplate boundaries based on Stoesser and Camp (1985).

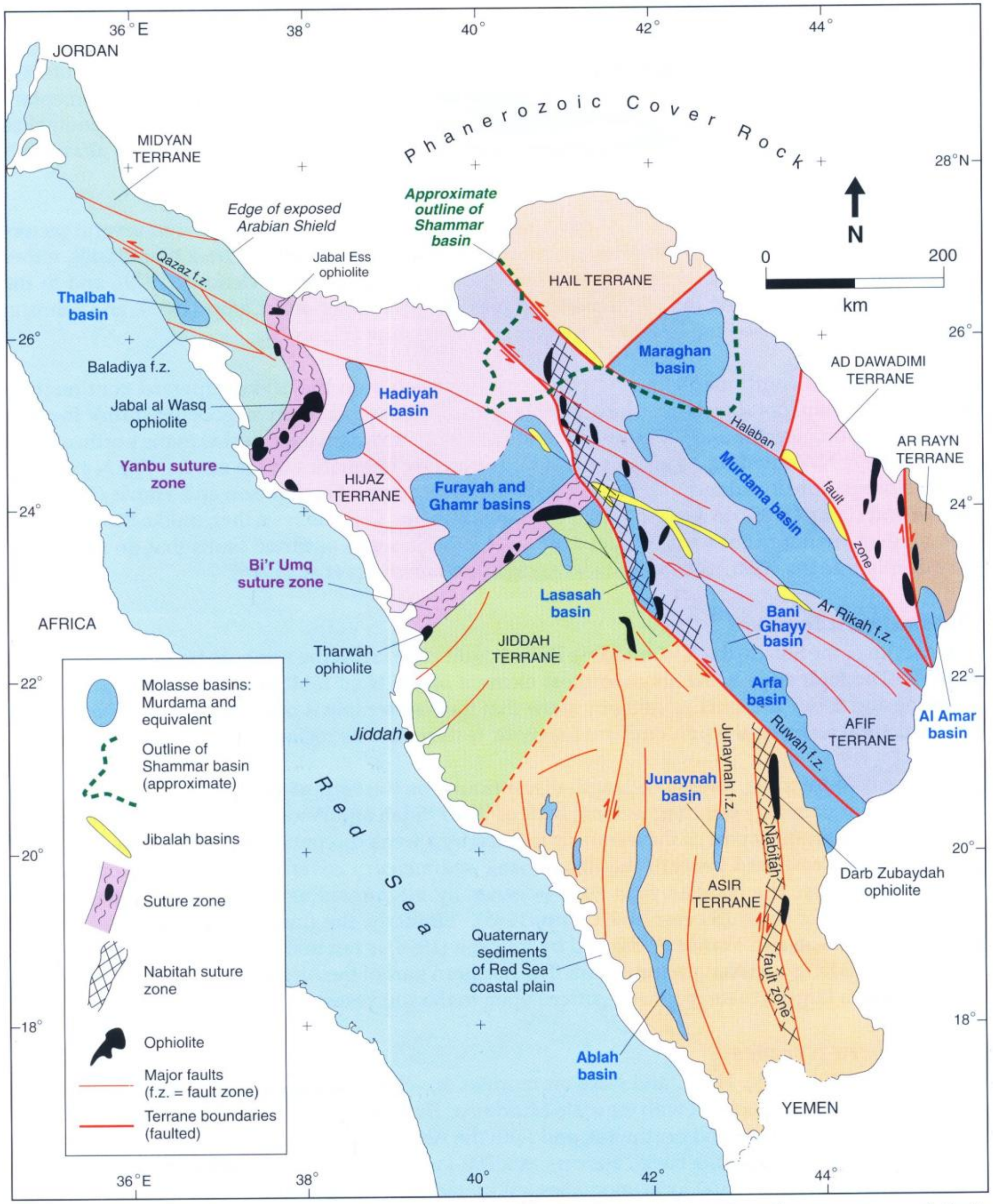


Figure 3: Simplified geologic sketch map of the Arabian Shield showing the terranes and their boundaries, and the main Pan-African structural features and sedimentary basins. Major fault zones, such as Ruwah, Ar Rikah, Halaban, and Qazaz, belong to the Najd fault system.

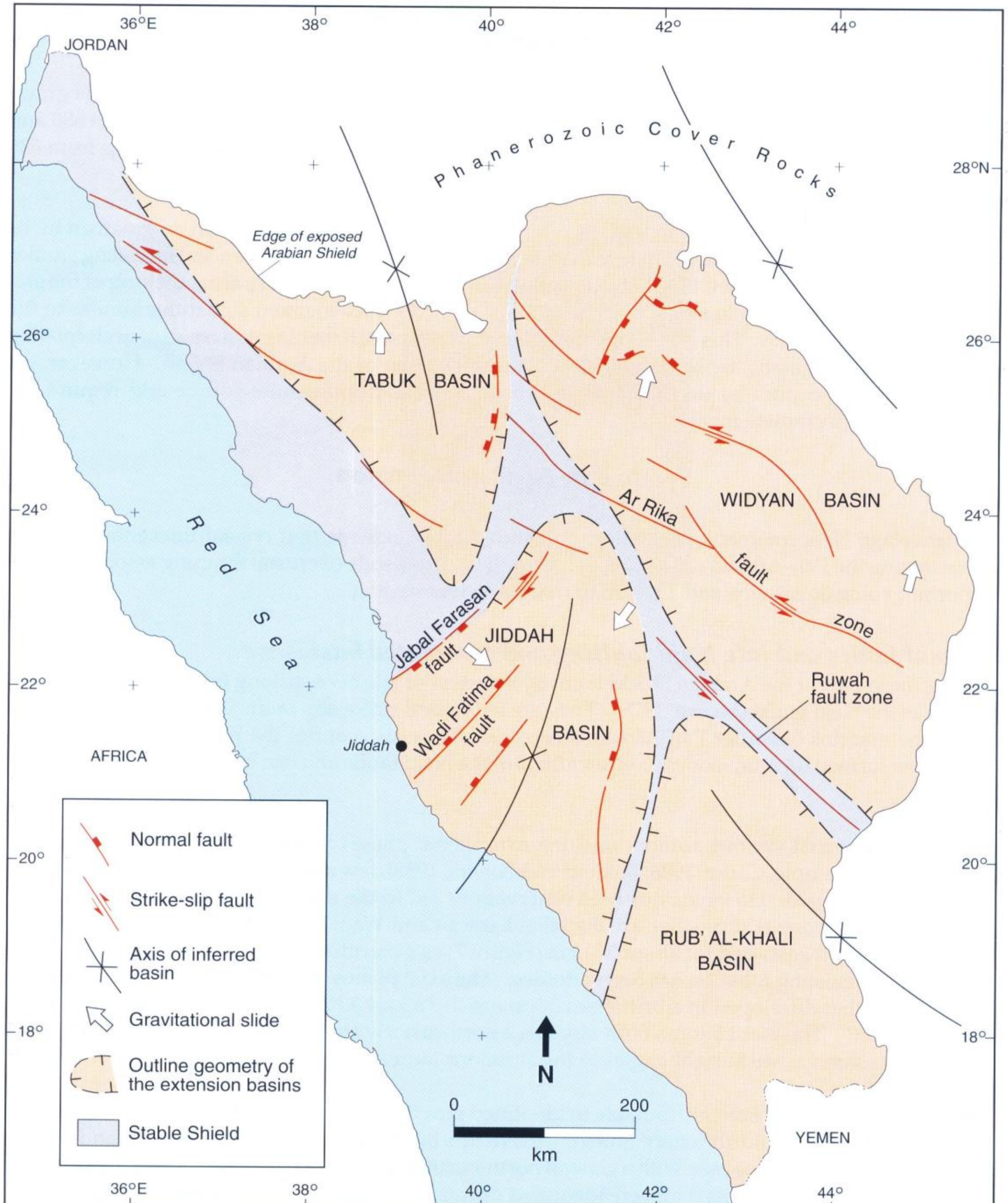
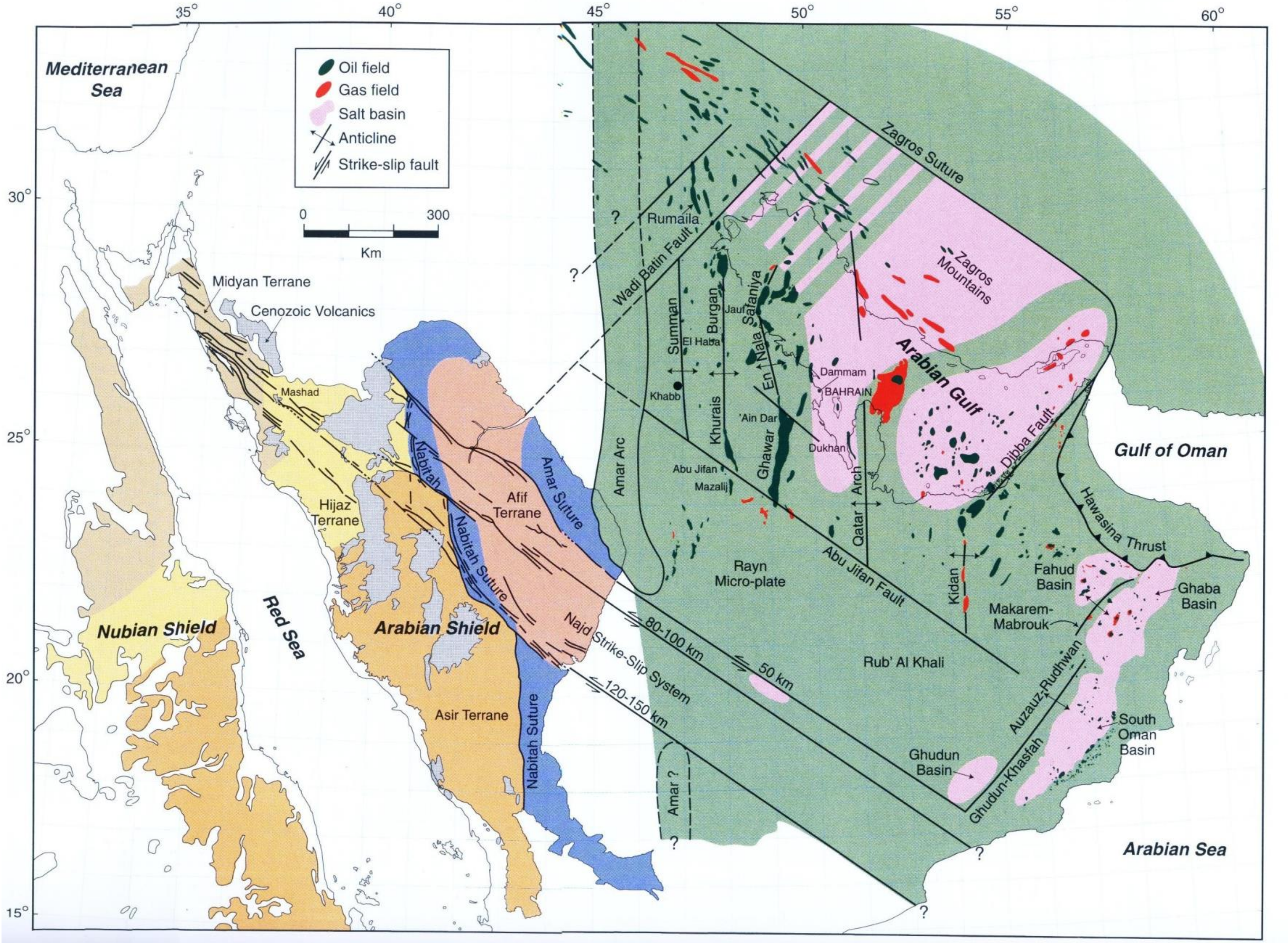
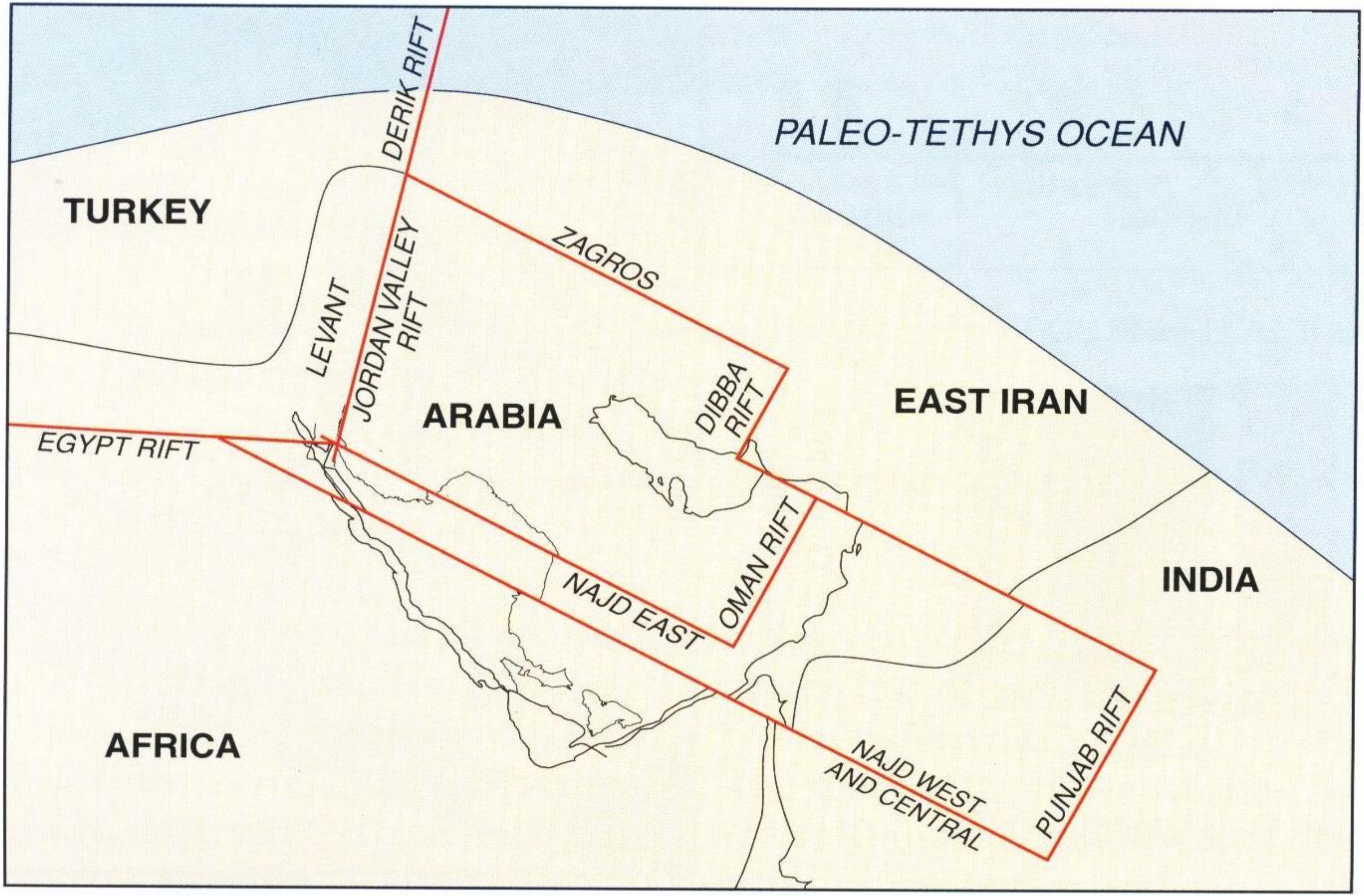


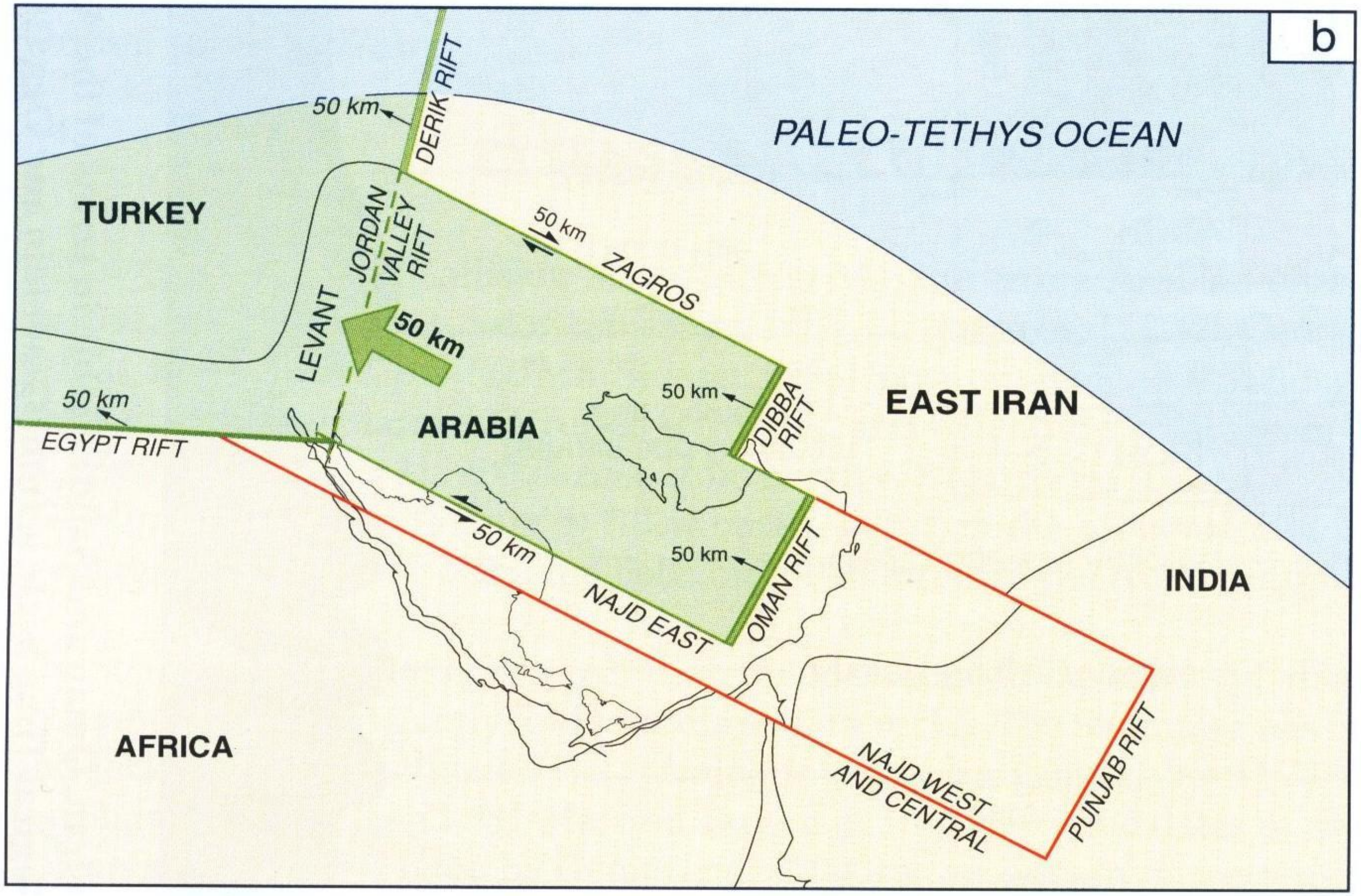
Figure 7: Simplified structural framework of Neoproterozoic extension in the Arabian Shield.



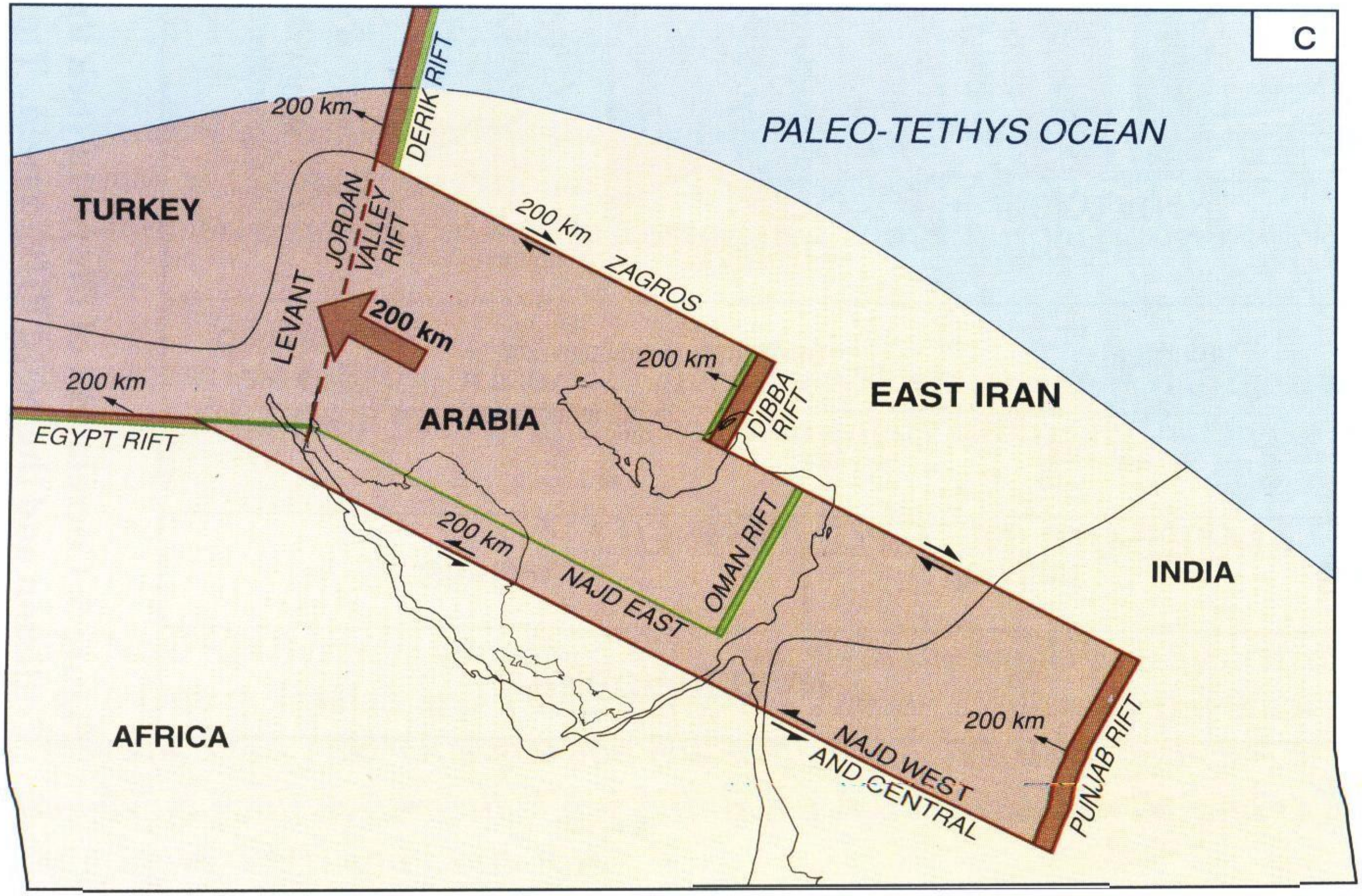
The Midyan, Hijaz, Asir and Afif terranes, and Amar Arc of the Rayn micro-plate form the Arabian Shield.



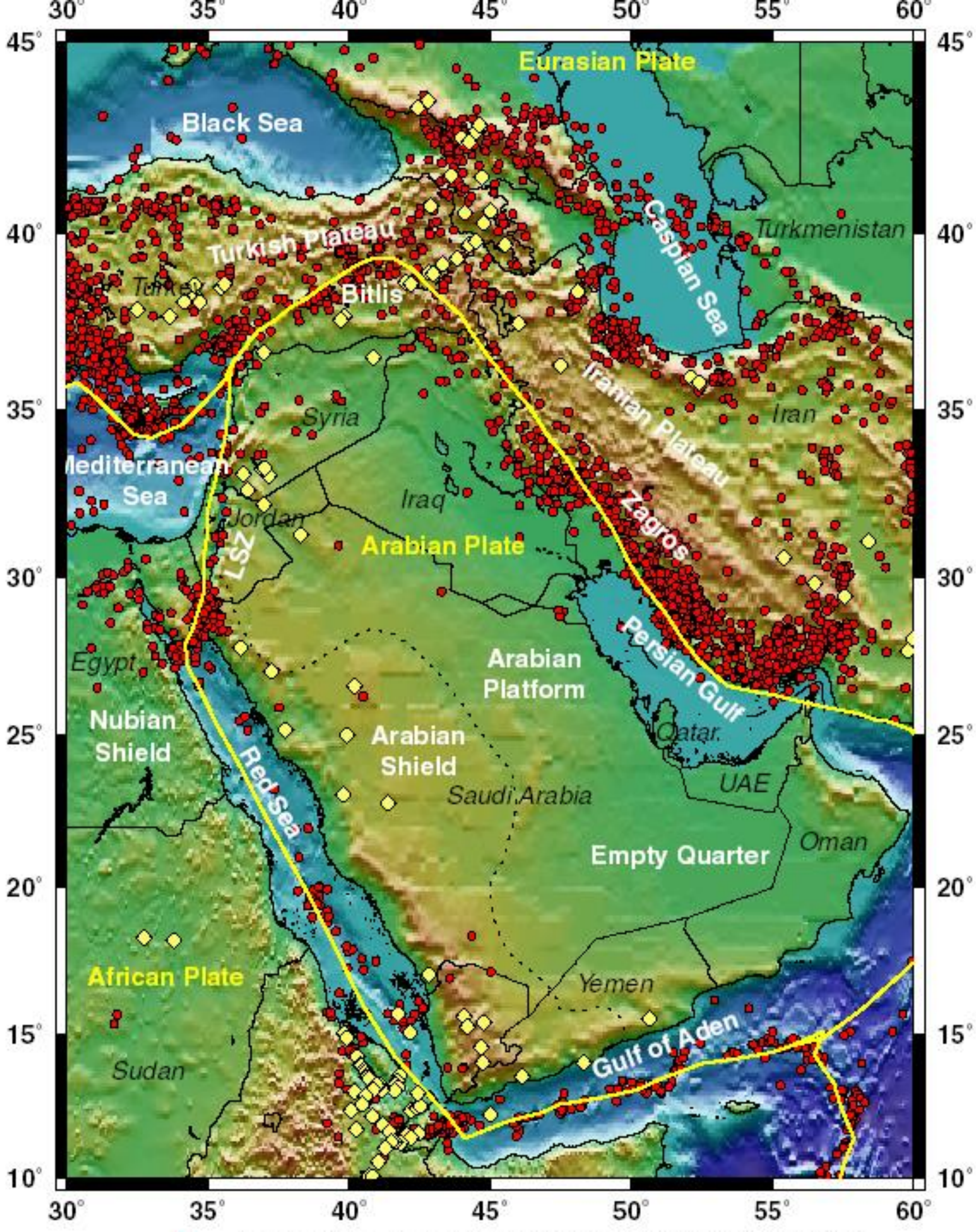
The Najd Rift System is restored to 570 Ma prior to the initiation of the Najd strike-slip System



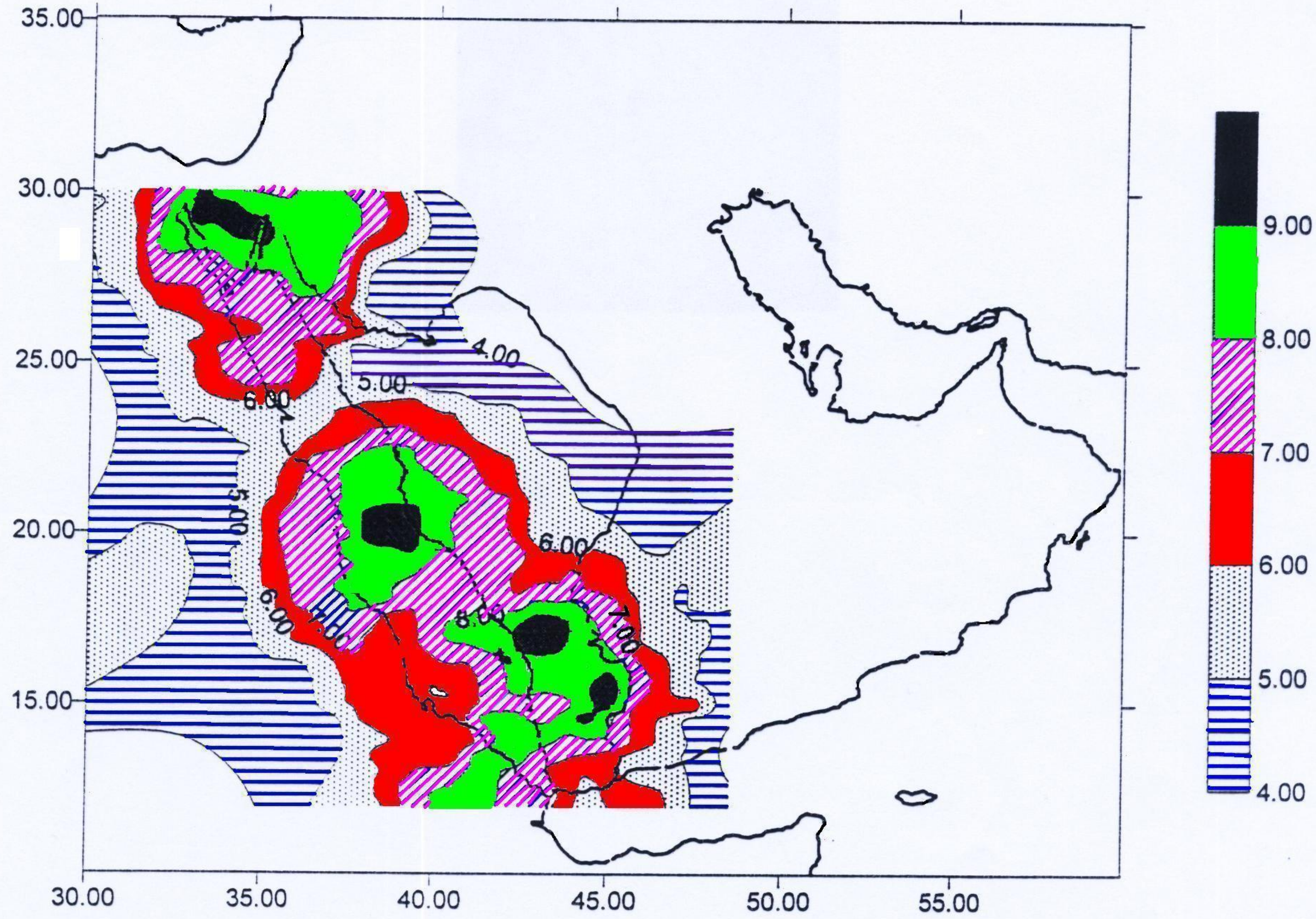
(b) A left-lateral dislocation of 50 km along the Najd East Fault corresponds to 50 km of rifting in the Oman and Dibba basins. This movement is accompanied by 50 km right-lateral movement along the Zagros Fault and a narrow rift along the Egypt and Derik branches of the Sinai Triple Junction.



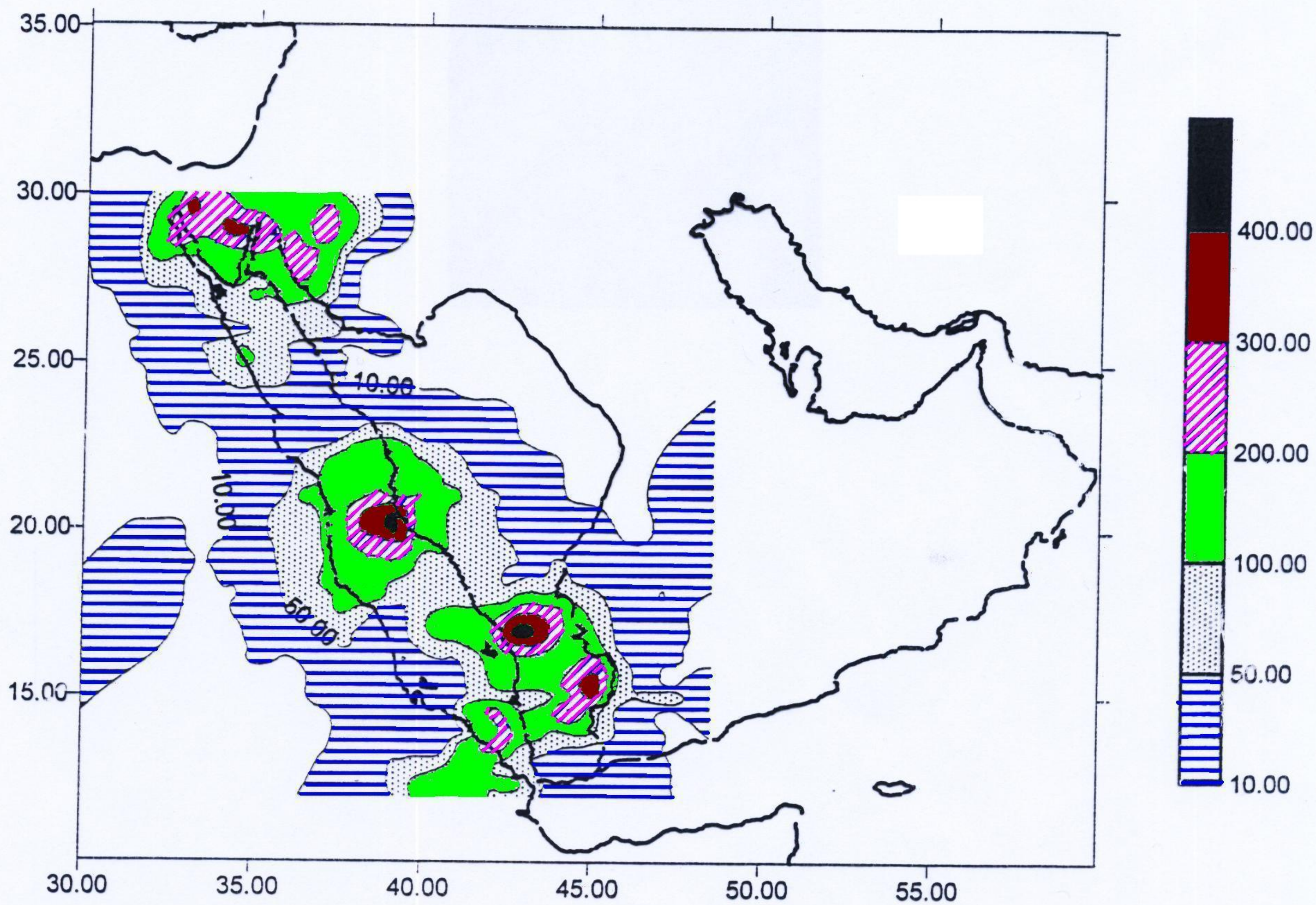
(c) A left-lateral dislocation of 200 km along the combined Najd Central and West faults (shown as one fault here) results in the opening of the Punjab Rift, and further extension along the other rift centers by 200 km. The steps shown in (b) and (c) may have occurred at the same time.



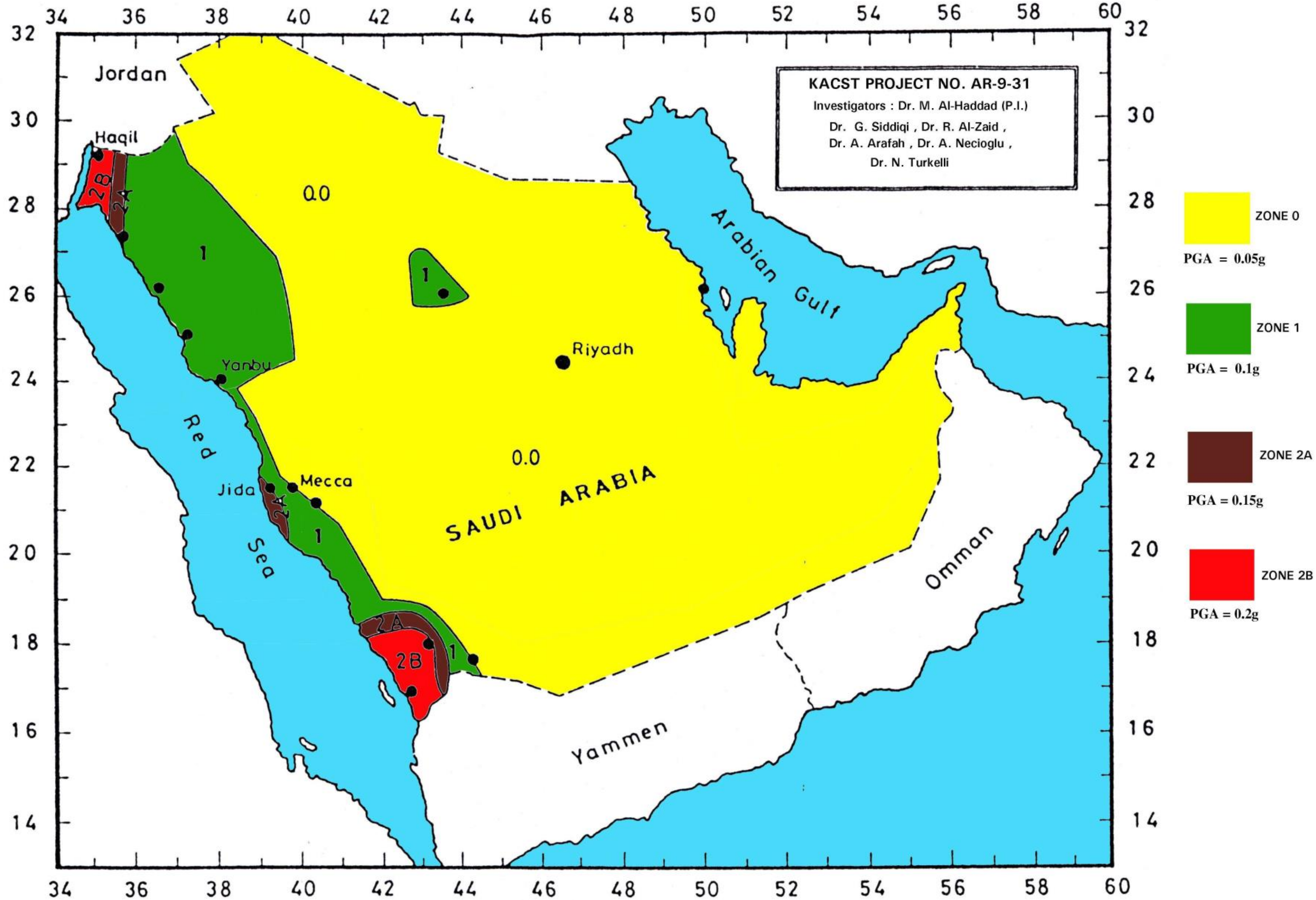
Seismotectonic map of the Arabian Peninsula.



Map of expected maximum intensity at 10% probability of exceedance in 50 years when variability is considered (Iv). Areas of concern which are covered by the range of intensity from VII to IX are broader than those covered by the mean maximum intensity.



Iso-acceleration map in gals at 10% probability of exceedance in 50 years obtained from conversion of the mean maximum intensity (I) to acceleration values.



Seismic Zonation Map

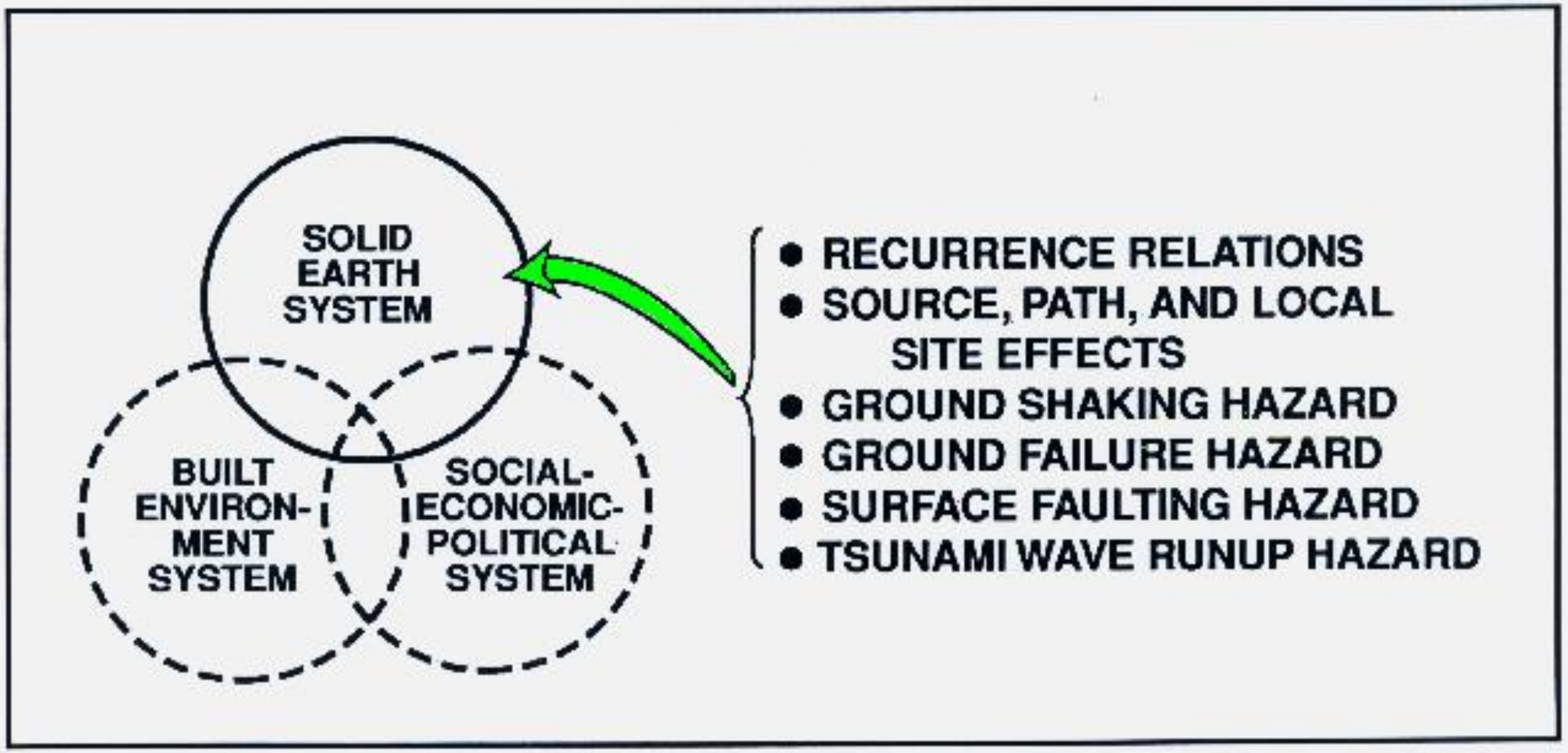
PGA = Peak Ground Acceleration

Seismic Hazard Program

- **Characterizing seismic sources**
- **Characterizing the attenuation rates of seismic wave propagation**
- **Characterizing the response to seismic waves of sites where structures and populations are located, and**
- **Probabilistic hazard assessment, a modeling procedure producing maps that engineers and policy makers can use to design an appropriate response to seismic hazards.**
- **By using a geographic information system (GIS) approach, we will generate seismic hazard maps by integrating the results of the above characterization steps and the probabilities of ground shaking and local site effects (soil-related amplification, soil liquefaction, and ground failure).**


شكراً

seismic zonation



Solid Earth System

The key questions are summarized as follows:

- Solid Earth System: i.e. Defines the physical Characteristics of the source, path, and site which control earthquake hazards.
- Where have earthquakes occurred in the past?
- Where are they occurring now?
- What is the magnitude and depth distribution of the past and present seismicity?
- How often have earthquakes of a given magnitude recurred?
- What are the dominant earthquake generating mechanisms?
- What levels of ground shaking have occurred in the past? Ground failure? Surface fault rupture? Tusnami wave runup?
- What are the maximum levels that might be expected in future earthquakes?

Built Environment System

The key questions are summarized as follows:

- **Built Environment System, (i.e., defines the temporal and spatial distribution of buildings and lifeline systems exposed to earthquak hazards).**

- **What are the physical characteristics of the present inventory of buildings and lifeline systems (e.g. age, type of materials, number of stories, elevation, plan, foundations, etc.) ? The future inventory?**

- **How have these buildings and lifeline systems performed in past earthquakes (e.g., what are the vulnerability relations for each type of building and lifeline)?**

- **. . . .**

Social Economic Political System

The key questions are summarized as follows:

- **Social-Economic- Political System, (I.e., defines the community;s earthquake risk management policies and practices (e.g., mitigation, preparedness, emergency, and recovery)).**

- **What risk management policies and practices (I.e., building and land use regulations) have been adopted by the community in the past?**

- **How have they been enforced?**

- **How effective have they been**

- **. . . .**

The Status of Seismic Zonation

Types of zonation Maps Being Produced

Ground motion

- ✓ **Intensity**
- ✓ **Peak acceleration**
- ✓ **Peak velocity**
- ✓ **Spectral response**

With consideration of the potential for soil amplification by the following types of soils:

 # S1 # S2 # S3 # S4

Ground Failure

@ Liquefaction @ Lateral spreads @ Landslides

Flood Waves

$ Tsunami $ Seiche

Scales

- **National / Regional**
  - ✓ **1 : 2,500,000 or smaller**
- **Subregional**
  - ✓ **1 : 250,000 or larger**
- **Urban**
  - ✓ **1 : 24,000   or larger**

Methods

Analytical Techniques

- Deterministic
- Probabilistic
- Statistical
- Other

Applications

To stop Increasing the Risk

- Building Codes
- Land Use Ordinances
- Urban / Regional Development Plans

To start Decreasing the Risk

- Structural Strengthening
- Non – structural detailing

To Continue Planning for the Inevitable

- Scenarios for Emergency Response
- Scenarios for Recovery and Reconstruction

Seismic Regionalization of the Arabian Peninsula

Seismic Regionalization of the Arabian Peninsula was partitioned into two primary stages.

- Identification and delineation of the seismogenic source zones.
- Determination of the seismicity and other related parameters of seismic concern.

In the identification and delineation of the seismogenic source areas, some criteria were followed and utilized as guidelines. These are mainly the seismological and geological parameters, and to lesser extent is the consideration of the geophysical parameters when needed.

- **The seismological parameter** is chiefly composed of the planar spatio-temporal distribution of earthquakes that indicates both seismogenic provinces and seismo-active faults, and occurrences of large earthquakes, the level of which depends upon the seismic activity in the region.

- **The geological parameter** is primarily a map of regional tectonics that shows the location of joints, faults, lineaments, and rift systems that are associated with the seismic activities in the area.
- **Geophysical parameters-** maps of heat flow and gravity anomaly distributions are useful in the interpretation on the nature of geologic structures

From these considerations, there were **twenty five (25)** identified and delineated seismogenic source zones.

DATA TREATMENT

- Non-duplication – separation of two or more seismic events should have 25 seconds difference in origin time, and for repetitive events, the USGS file is given preference in the selection.
- Reduction of cluster events - three procedures in the reduction of cluster events which may be composed of foreshocks, aftershocks, and swarms types can be referred for this treatment

- Completeness of seismic data. Several factors are involved in this process. These are absence, insufficiency, and low detection capability of instrumentation, scarcity and inadequacy of physical factors involved in macroseismic observations, and lack of appropriate conversion equations from one set of seismic parameter to another. Reliability may range from 0.2-0.5 degree in distance, 0.5 in magnitude, and one degree scale in intensity are possible to attain in the procedure of completion.
- Missing magnitudes are not included for there are no adequate and sufficient information regarding the occurrences of these seismic events.

Seismicity parameters for seismic zones in the Arabian Peninsula

Zone No.	Name	Seismicity Parameters		
		A	B	Mag_{max}
1	Gulf of Suez	4.66	0.67	7.0
2	Gulf of Aqaba-Dead Sea	4.93	0.67	7.4
3	Tabuk			
4	Northwestern Volcanic Zone			
5	Midyan-Hijaz			
6	Duba-Wajh Area	4.77	0.82	5.8
7	Yanbu			
8	Southern Red Sea-Jeddah	4.67	0.7	6.7
9	Makkah Region			
10	Southern Red Sea-Al Darb	5.14	0.75	6.9

Zone No.	Name	Seismicity Parameters		
		A	B	Mag_{max}
11	Abha-Jizan	3.08	0.55	5.6
12	Southwestern Arabian Shield	3.62	0.5	7.2
13	Gulf of Aden	4.71	0.67	7.0
14	Sirhan-Turayf-Widyan Basins	3.21	0.59	5.4
15	Najd Fault Zone	2.34	0.59	4.6
16	Central Arabian Graben Zone	3.64	0.66	5.5
17	Arabian Gulf	4.02	0.65	6.2
18	Zagros Fold Belt	6.83	0.94	7.2

Zone No.	Name	Seismicity Parameters		
		A	B	Mag_{max}
19	Sanandaj-Sirjan Ranges	5.84	0.84	6.9
20	Southern Yemen			
21	Rub Al Khali-Ghudun Basins	2.42	0.51	4.8
22	Bandar Abbas-Dibba Region	7.15	1.0	7.2
23	Makran-Hawasina Thrust Zone	3.35	0.59	5.7
24	East Sheba Ridge	6.06	0.85	7.1
25	Masirah Fault Zone	4.35	0.71	6.1

MODELING OF SEISMIC ZONES

1. Correlation between seismic and tectonic data

(a) Earthquakes do not occur everywhere, but only in definite tectonically active areas and in strong accordance with movement and deformation of geological structures.

(b) Major earthquakes occur along tectonically active source zones having large faults.

(c) Geological structures move abruptly on faults along tectonically homogeneous active zone not simultaneously but alternatively in different places of the zones.

2. Correlation between Earthquake Frequency and Mechanics of Faulting

Seismic Source Zones of the Arabian Peninsula

Zone No.	Name	Cooridinates		Area (KM^2)
		Lat. N	Long. E	
1	Gulf of Suez	30.28	31.23	32058
		31.27	32.22	
		27.14	33.87	
		27.81	34.70	
2	Gulf of Aqabah-Dead Sea	32.31	35.22	43050
		32.28	36.48	
		28.33	33.30	
		27.81	34.73	
		28.81	34.02	
3	Tabuk	32.28	36.48	85032
		29.33	35.62	
		28.29	39.75	
		26.35	37.73	

4	Northwestern Volcanic Zone	26.35	37.73	98618
		22.36	40.81	
		23.33	41.72	
		28.29	39.75	
5	Midyan-Hijaz	28.33	35..30	36638
		29.33	35.62	
		21.72	40.24	
		22.36	40.81	
6	Duba-Wajh Area	28.33	35.30	67476
		26.62	33.25	
		23.82	35.74	
		25.62	37.58	
7	Yanbu	23.82	35.74	49614
		25.62	37.58	
		21.34	37.22	
		23.37	39.26	
8	Southern Red Sea-Jeddah	21.34	37.22	78009
		23.37	39.26	
		18.20	38.82	
		19.58	41.42	
9	Makkah Region	21.72	40.24	44958
		23.33	41.72	
		18.83	41.84	
		20.62	43.35	

10	Southern Red Sea-Al Darb	18.20	38.82	112358
		19.58	41.42	
		15.88	43.44	
		12.65	42.98	
11	Abha-Jizan	18.83	41.84	44958
		20.62	43.35	
		15.88	43.44	
		17.32	45.27	
12	Southwestern Arabian Shield	15.88	43.44	67323
		12.65	42.98	
		17.32	45.27	
		13.66	46.18	
13	Gulf of Aden	12.65	42.98	335851
		10.37	44.23	
		16.12	54	
		14.05	54.61	
14	Sirhan-Turayf-Widyan Basins	32.28	36.48	343516
		32.01	47.13	
		26.46	41.72	
		28.29	39.75	
15	Najd Fault Zone	28.29	39.5.75	379730
		20.62	48.36	
		17.32	45.27	
		20.2	43.1	
		23.33	41.75	

16	Central Arabian Graben Zone	26.46	41.72	533174
		30.86	46.02	
		23.52	51.46	
		20..62	48.36	
17	Arabian Gulf	30.86	46.02	257798
		32.01	47.13	
		25.96	54.17	
		23.52	51.46	
18	Zagros Fold Belt	32.01	47.13	160644
		32.01	50.11	
		27.31	55.6	
		25.96	54.17	
19	Sanandaj-Sirjan Ranges	32.01	50.11	148636
		32.0	53.84	
		28.8	57.3	
		27.31	55.6	
20	Southern Yemen	17.32	45.27	408636
		20.62	48.36	
		16.12	54.0	
		13.66	46.18	
21	Rub Al Khali-Ghudun Basins	20.62	48.36	403580
		24.16	52.22	
		19.69	57.32	
		16.12	54.0	
		18.02	55.62	

22	Bandar Abbas-Dibba Region	24.16	52.22	140096
		28.8	57.3	
		27.5	58.48	
		22.85	53.76	
23	Makran-Hawasina Thrust Zone	22.85	53.76	324060
		27.5	58.48	
		24.88	61.68	
		19.69	57.32	
24	East Sheba Ridge	16.12	54.0	209585
		18.02	55.62	
		14.09	59.46	
		11.99	57.44	
		14.05	54.61	
25	Masirah Fault Zone	18.02	55.62	238136
		24.88	61.68	
		14.09	59.46	
		19.69	57.34	

Characterization of the Seismogenic Source Zones

The characterization of the seismogenic source zones is composed of two parts.

- Association of each source zone to the tectonic and seismicity model of the areas contained in each source zone.
- Logic tree diagram for graphical description of the physical and seismicity parameters involved in seismotectonic correlation.

METHODOLOGY

Two methods of approach were employed in the study. These are seismicity and fractures.

- Under the seismicity approach, the set of seismic data in each source zone was utilized to plot the magnitude-frequency relation, and for the estimation of the linear seismic slip and seismic moment release rates. From the frequency graphs, the respective seismicity parameters were determined for correlation to tectonic structures and probable earthquake source mechanisms.
- Under the second approach, the tectonic structures contained in each source zones were examined based on existing geological/tectonic maps for identification and association to the types of earthquake source mechanisms, and to the seismicity of the source area.

- Combination of the two approaches lead to the preliminary framework of a seismotectonic model for each seismogenic source zone.
- From the findings, there were at most two types of sources for the tectonic model. These are the fault and area source.
- Under the fault source are the transcurrent and normal faults and their respective variations.
- Under the area source are the seismic events not directly associated to known presence of fractures or are off located, and or the sudden or randomly distributed dislocations of the ground within the source zones

Seismic Source Zones

Because of the broad scale of this analysis and the lack of information about active fault sources in the Arabian Peninsula, seismic sources are represented as continues zones of seismicity that exhibit similar styles and rates.

The geologic parameters that define the source zones are :

(1) Map and downdip geometry of faults (e.g., location, length, orientation, dip, and total depth)

(2) Sense of slip on the faults; and

(3) Timing of the fault activity (e.g., amount of slip).

- Seismological parameters used to characterize the source zones include hypocentral locations of earthquakes, the magnitude-frequency distribution of reported earthquake focal mechanisms.

- Typically, the boundaries of the source zones are major tectonic or geologic discontinuities that appear related to a change in seismotectonic character between adjacent source zones.

Maximum Magnitudes

Several fault parameters were used to develop maximum earthquake magnitudes. For source zones, these include

- historical seismicity
- seismogenic depth of faulting
- tectonic model.

Additional parameters that can be applied to fault sources are:

total fault length, fault width, segmentation, rupture length, rupture area.

Source Zones

- Uncertainties in the source characterization parameters are incorporated into each source zone model in the form of logic trees.
- Logic trees are composed of nodes and branches. Each node represents a point at which there is a choice between two or more values or conditions for one parameter.
- Each branch represents the value of an input parameter. Each branch is assigned a probability that represents the value likelihood of that branch being the correct value or condition of the input parameter. The use of logic trees can account for uncertainties due to lack of data.

Gulf of Suez and Gulf of Aden Marginal Rift and Yemen Transition Zone

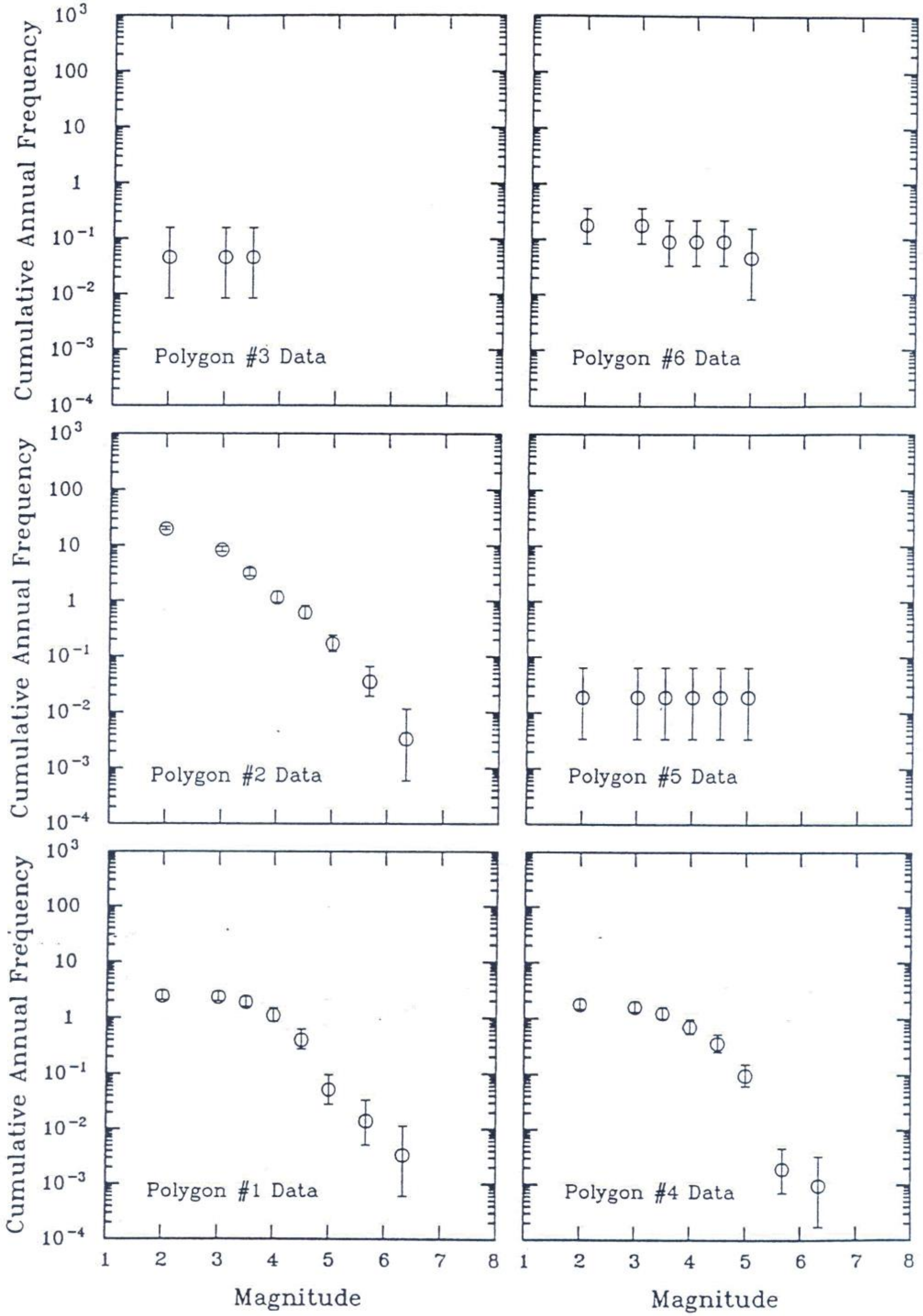
Source Zone	Style of Faulting	Rate of Deformation	Crustal Thickness
Red Sea Marginal Rifts	Normal : N30W/60E N30W/60W Strike-slip: N10E/90	Northern Red Sea No Oceanic Crust Normal : 6.3 mm/yr 120 km Oceanic Crust Normal: 1.5 mm/yr Strike-Slip: 7.5 mm/yr Southern Red Sea 100 km Oceanic Crust (Total Extension 60%) Normal: 5.6 mm/yr Strike-slip : 2.8 mm/yr (Total Extension 110%) Normal: 7.8 mm/yr Strike-Slip: 3.9 mm/yr 330 km Oceanic Crust (Total Extension 60%) Normal: 1.5 mm/yr Strike-slip : 0.75 mm/yr (Total Extension 110%) Normal: 2.0 mm/yr Strike-Slip: 1.0 mm/yr	Northern Red Sea 18-32 km Southern Red Sea 11-38 km

Cont.

Source Zone	Style of Faulting	Rate of Deformation	Crustal Thickness
Yemen	Normal: N30W/60SW N70W/60S	NA	11-38 km
Aden Marginal Rifts	Normal: N70W/60S,N	NA	NA

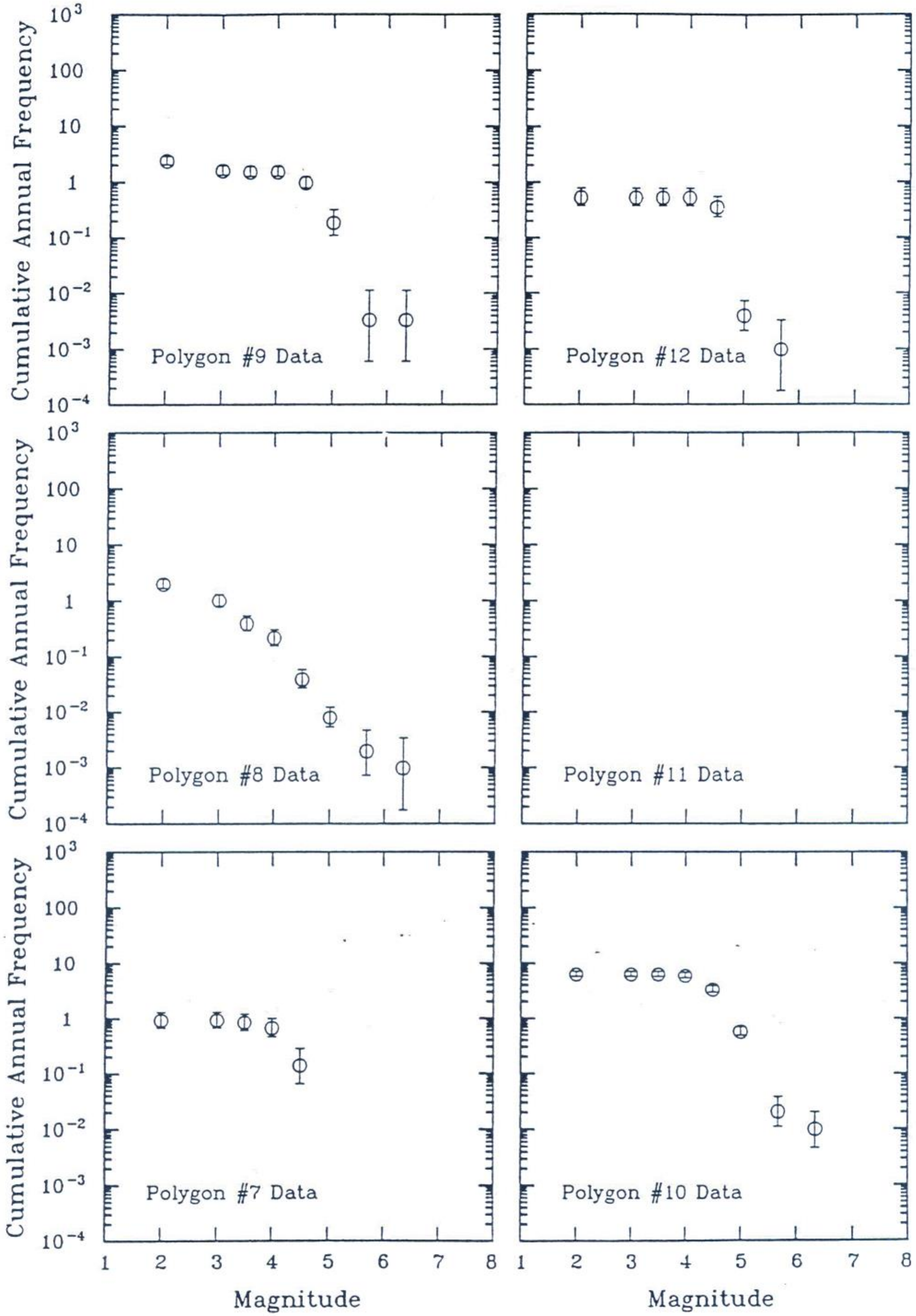
Red Sea and Gulf of Aden Axial Rifts

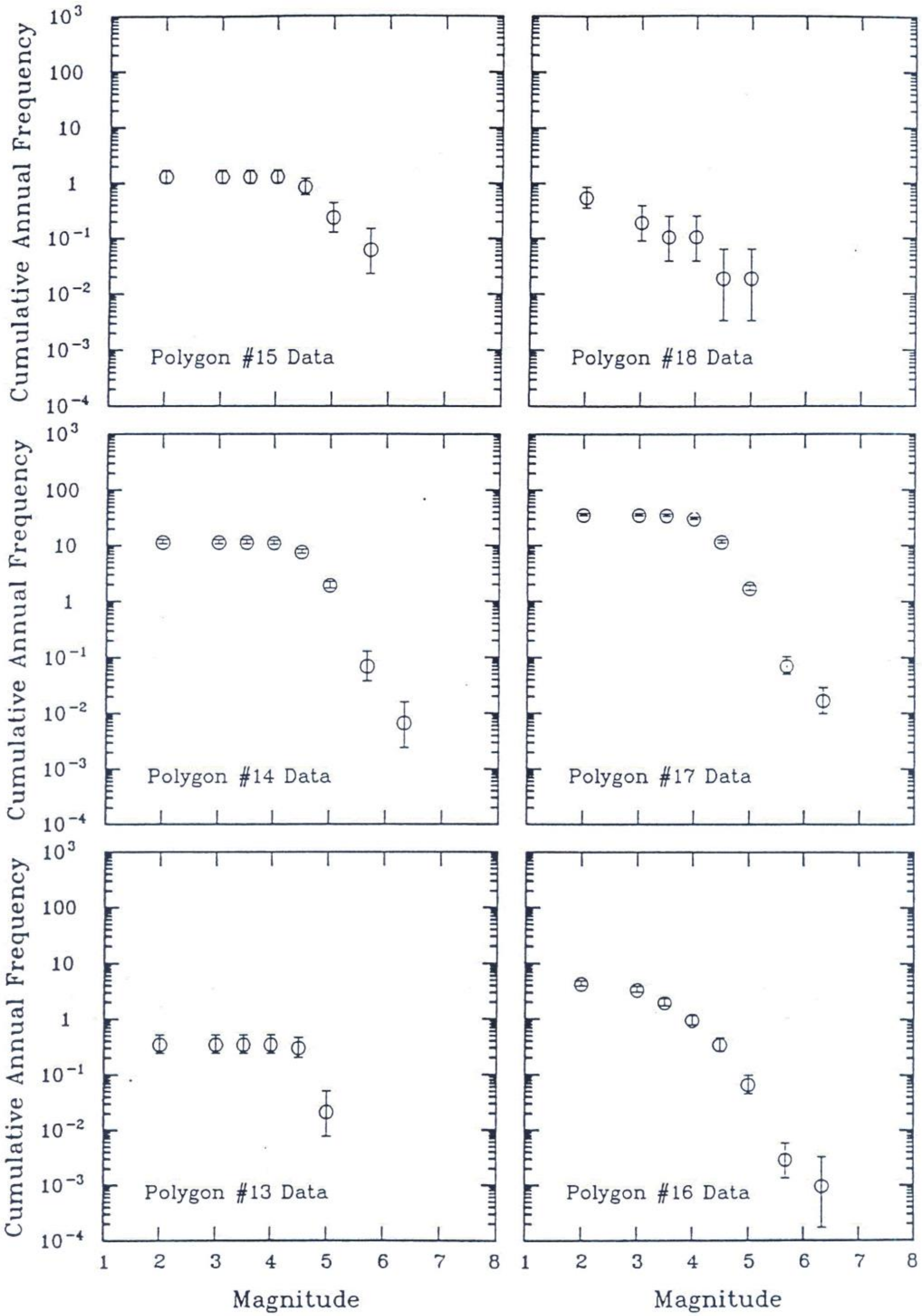
Red Sea Axial Rifts	Normal: N30W/60SW,NE Strike-slip: N10E/90 (Transform) Volcanic: Geometry High Variable	Northern Red Sea Normal: NA Transform: 5.0 to 9.8 mm/yr Volcanic: NA Southern Red Sea Normal: NA Transform: 8 to 15.4 mm/yr Volcanic: NA	18 km 5-8 km
Aden Axial Rift	Normal: N70W/60S,N Strike-slip: N30E/90 (Transform) Volcanic: Geometry Extremely Variable	Normal: NA Strike-slip: 17.2-30.2 mm/yr (Transform) Volcanic: NA	NA



Cumulative regional recurrence rates for earthquakes located in distributed seismicity zones

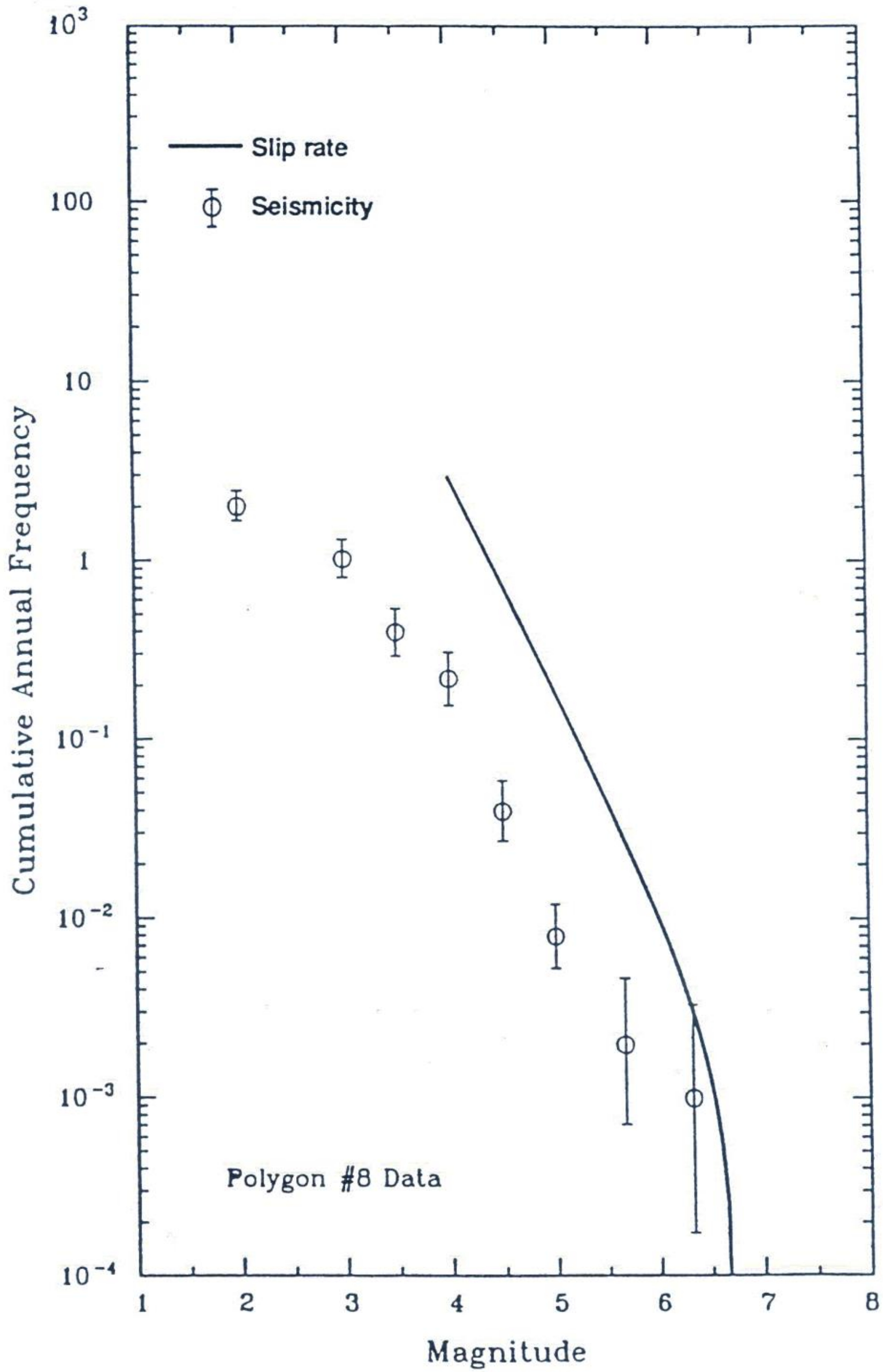
Cumulative regional recurrence rates for earthquakes located in distributed seismicity zones

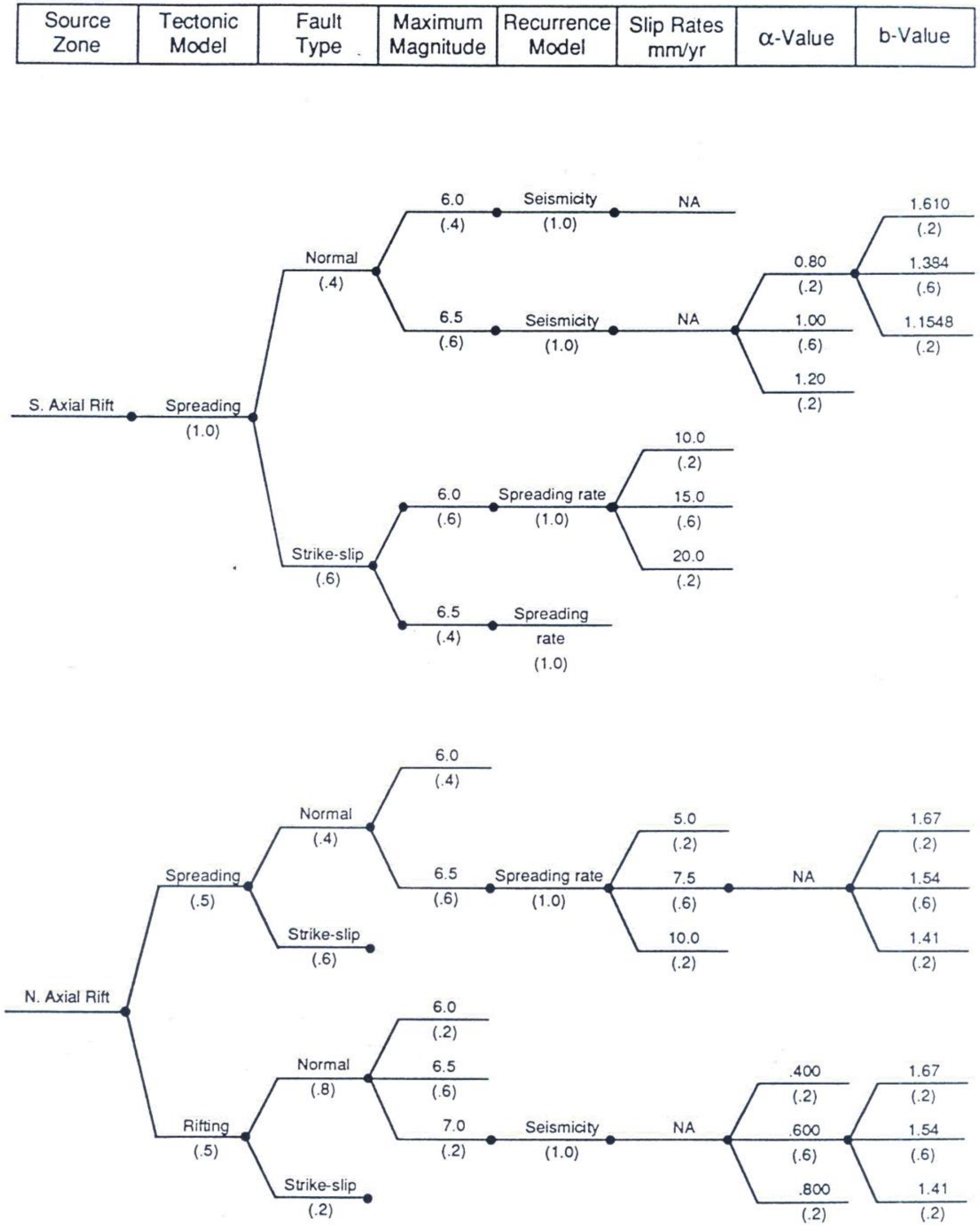




Cumulative regional recurrence rates for earthquakes located in distributed seismicity zones

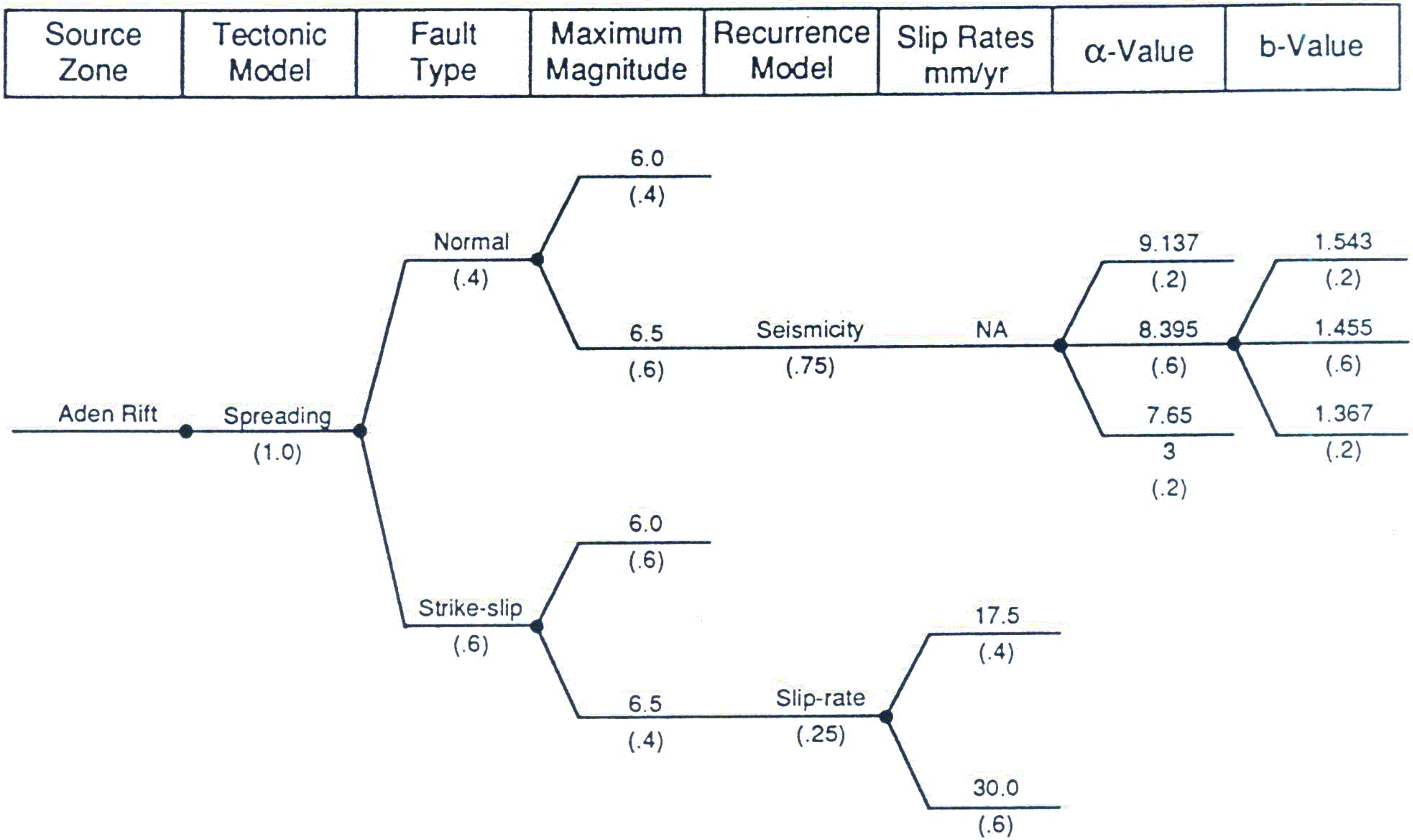
Comparison of observed seismicity and seismicity from preliminary assessment of vertical slip rates along the Red Sea eastern marginal rift





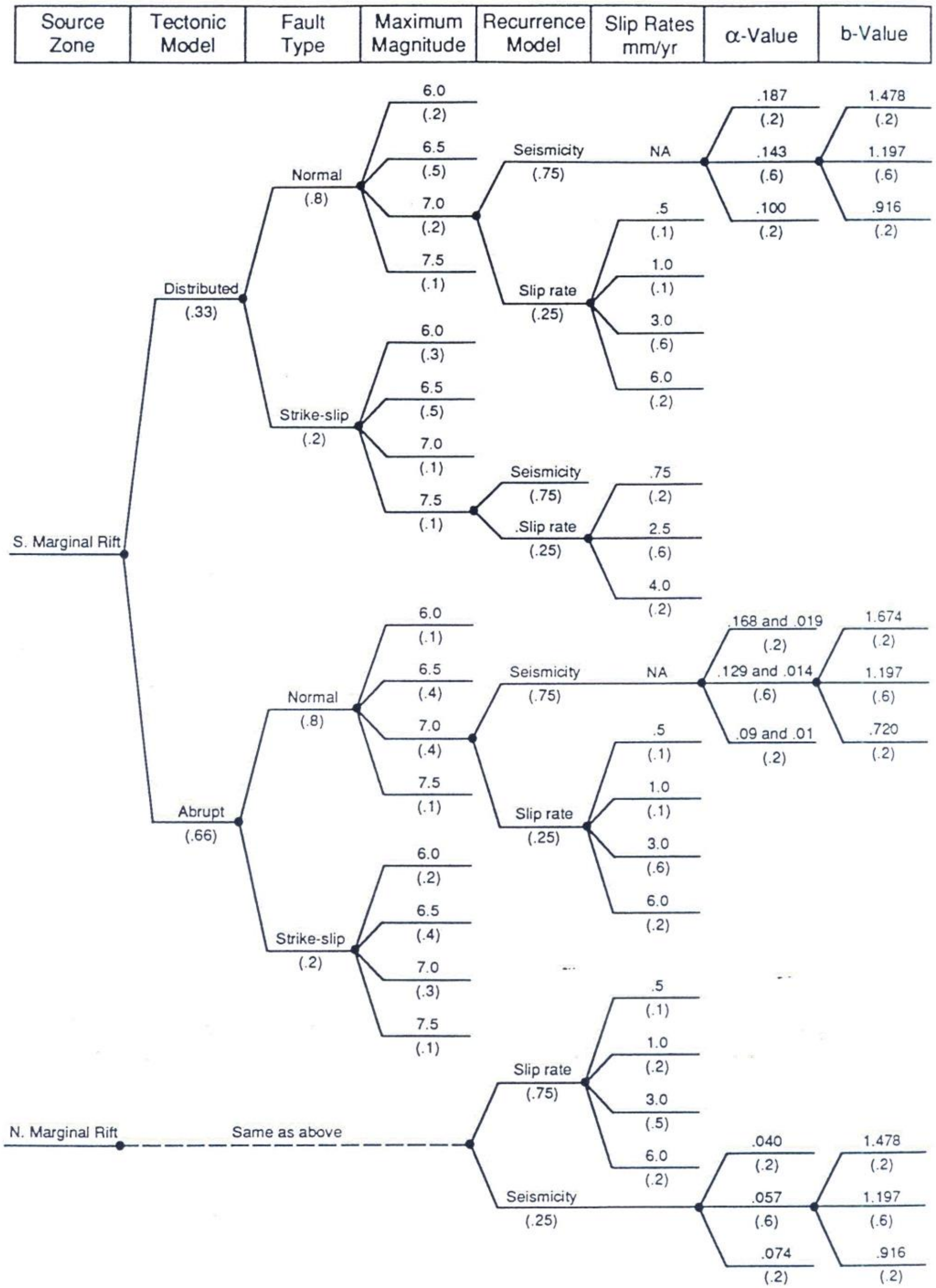
Source Zone of

Red Sea Axial Rift

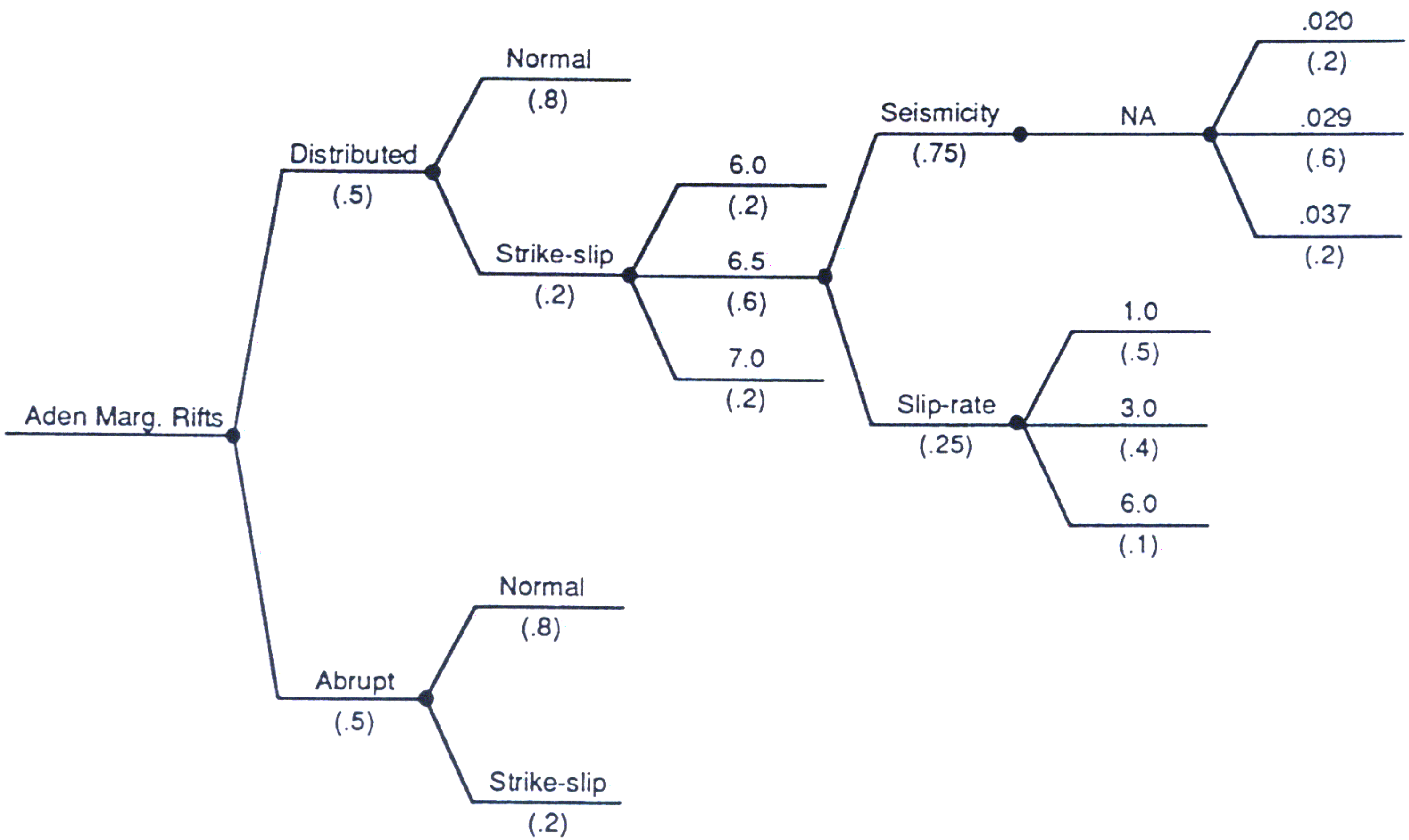


Source Zone Logic Tree for the Aden Axial Rift

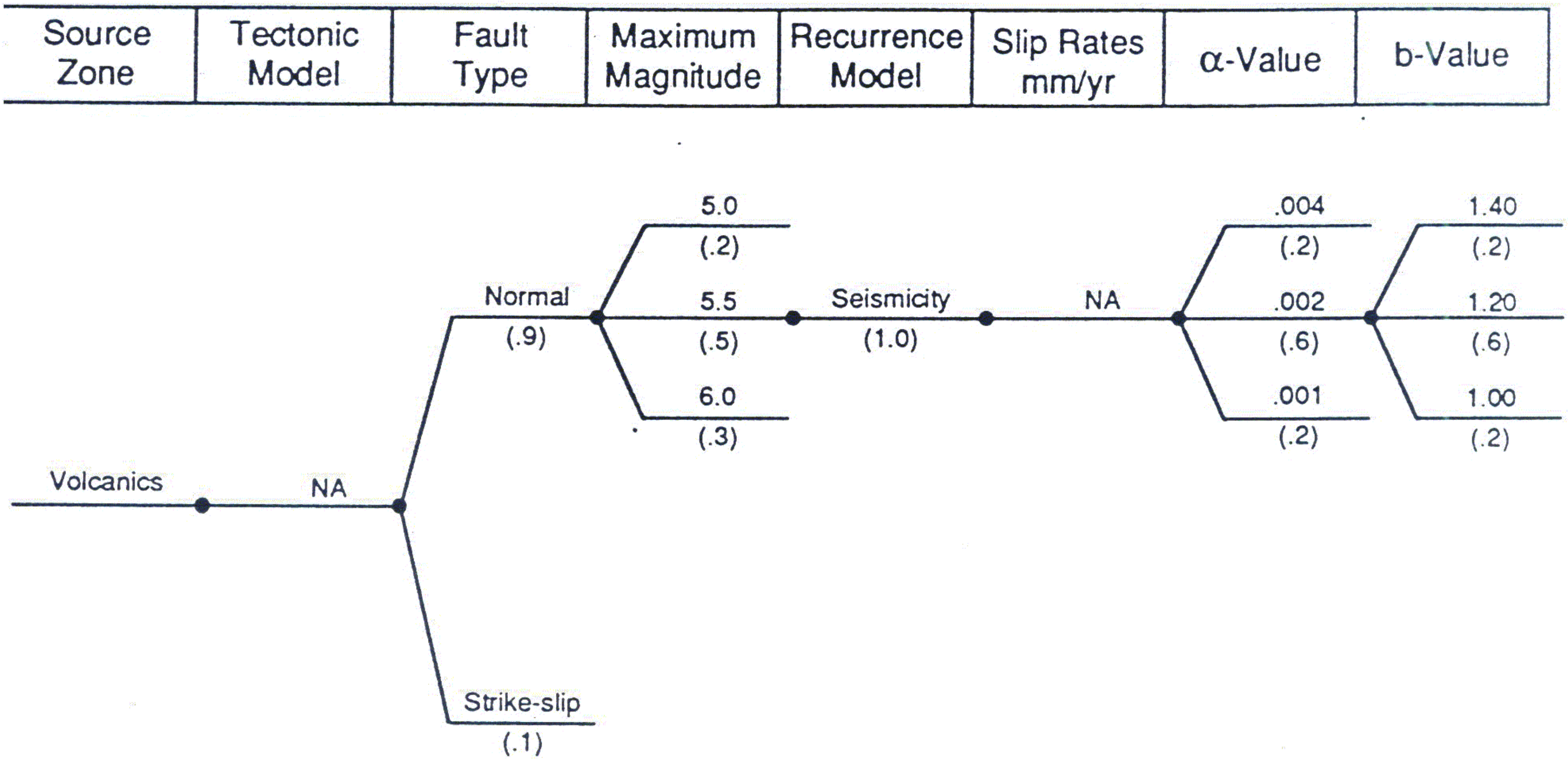
Source Zone for the Red Sea Marginal Rift



Source Zone	Tectonic Model	Fault Type	Maximum Magnitude	Recurrence Model	Slip Rates mm/yr	α-Value	b-Value

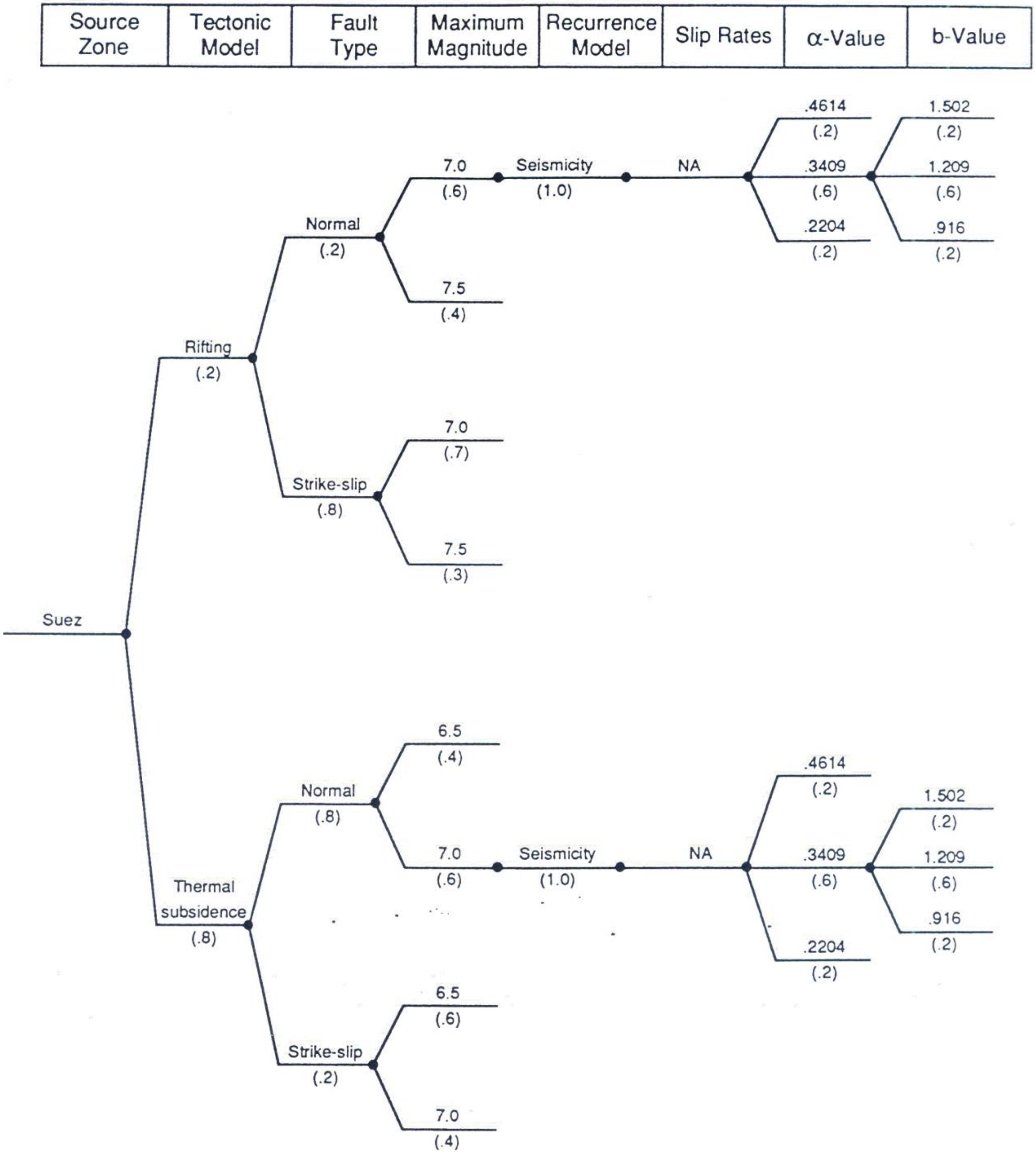


Source Zone Logic Tree for the Gulf of Aden Marginal Rift



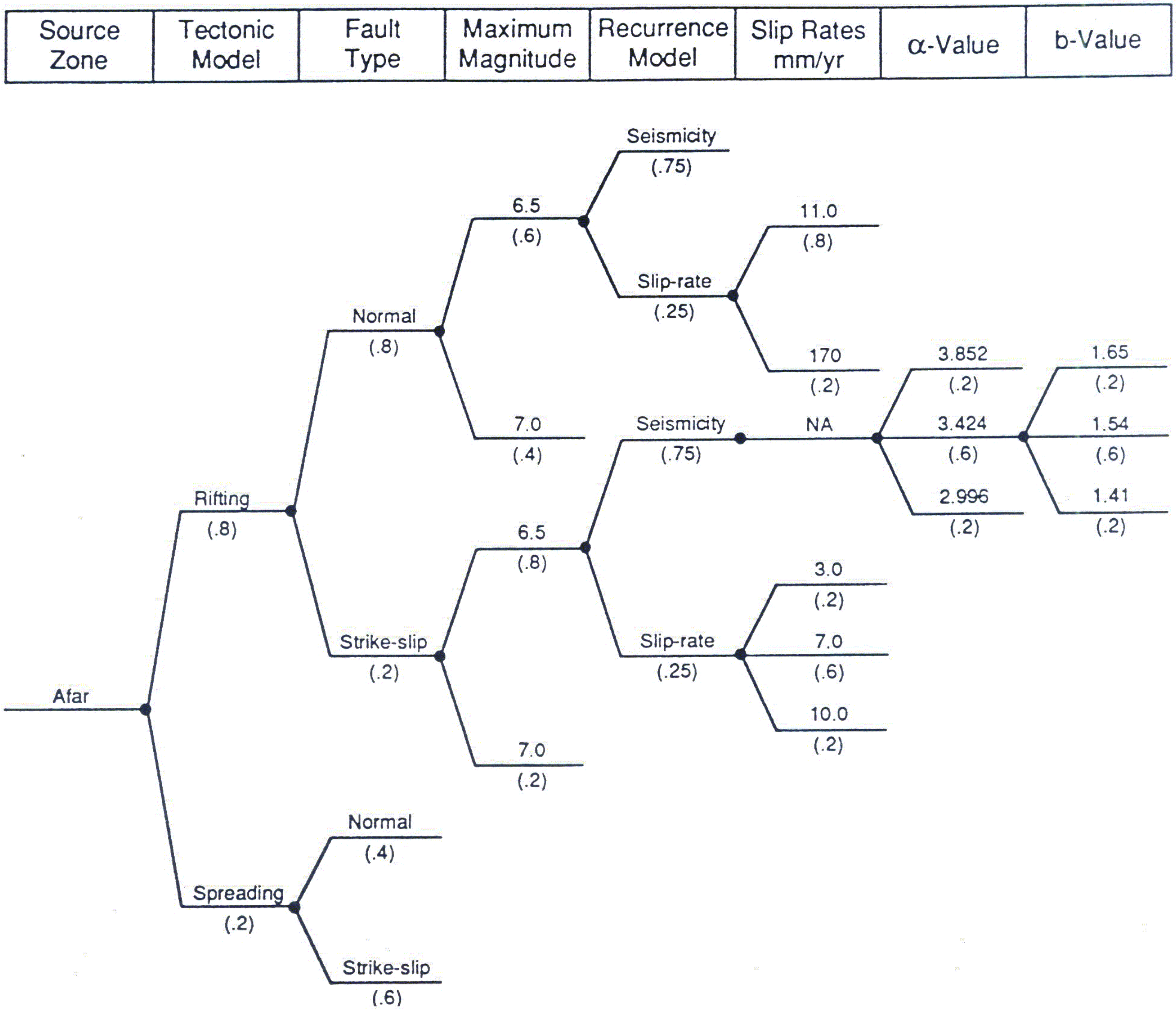
Source Zone Logic Tree for

the Marginal Rift Volcanics



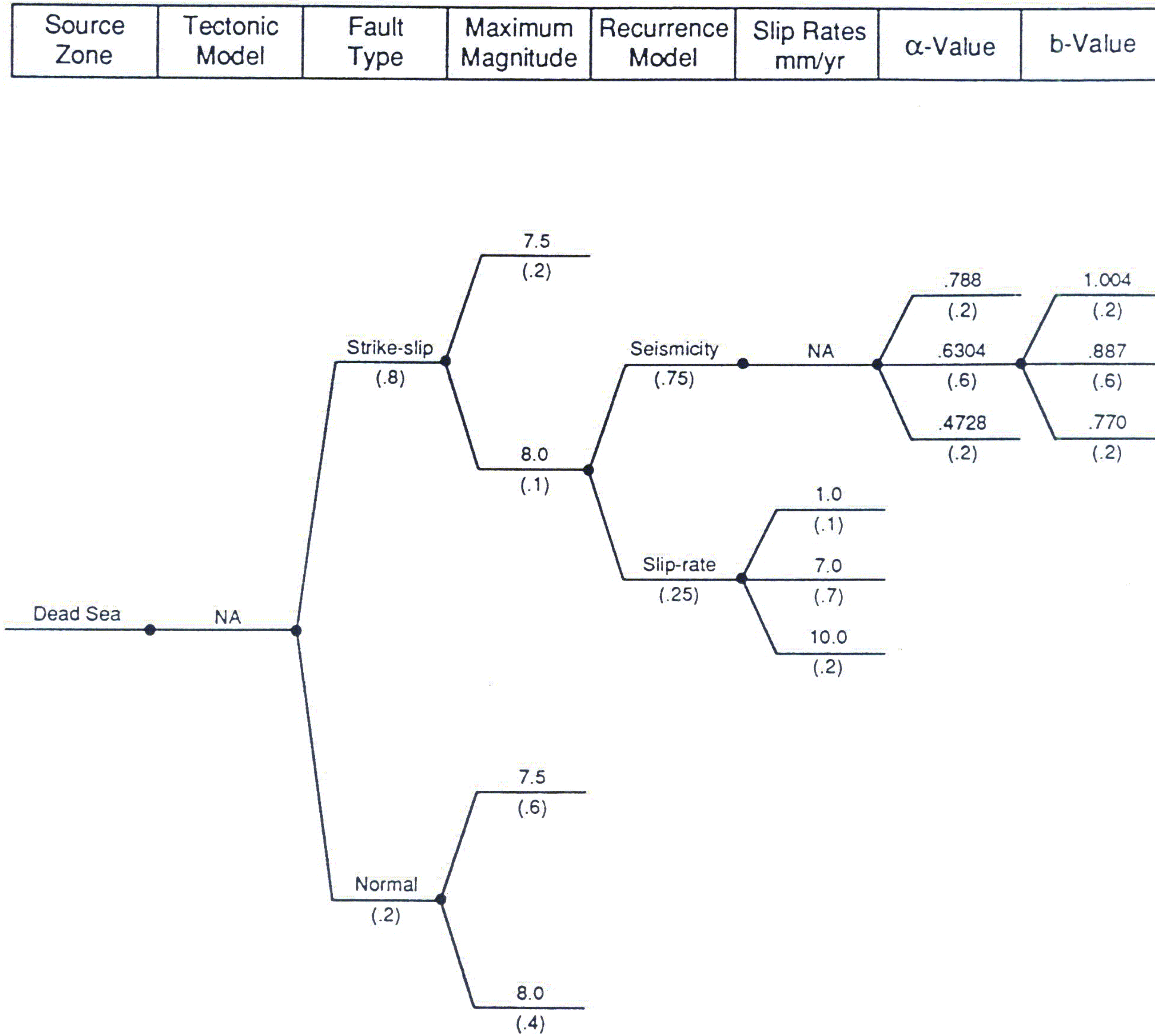
Source Zone Logic Tree for the Gulf of Suez

Source Zone Logic Tree for the Afar Source Zone Depression

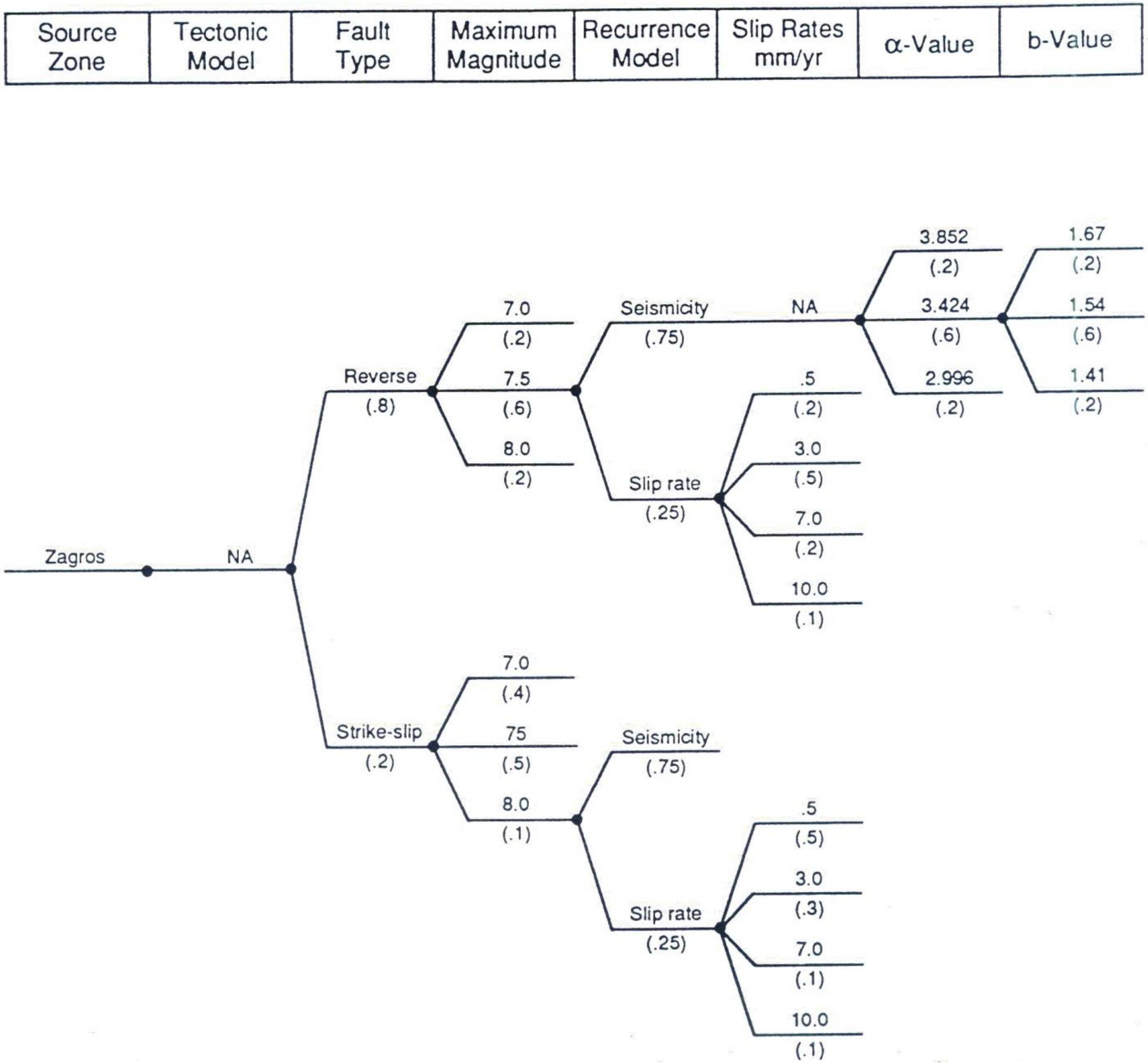


Source Zone Logic Tree for the Afar Source Zone Depression

Source Zone Logic Tree for the Dead Sea Source Zone



Source Zone Logic Tree for the Dead Sea Source Zone



Source Zone Logic Tree for the Zagros Collisional Belt

Source Zone Logic Tree for the Zagros Collisional Belt

M_{max}( ) : Expected maximum magnitude. Letter inside parenthesis means the source from which M_{max} is taken. S=seismicity, O=observation, L=fault length, A=assigned

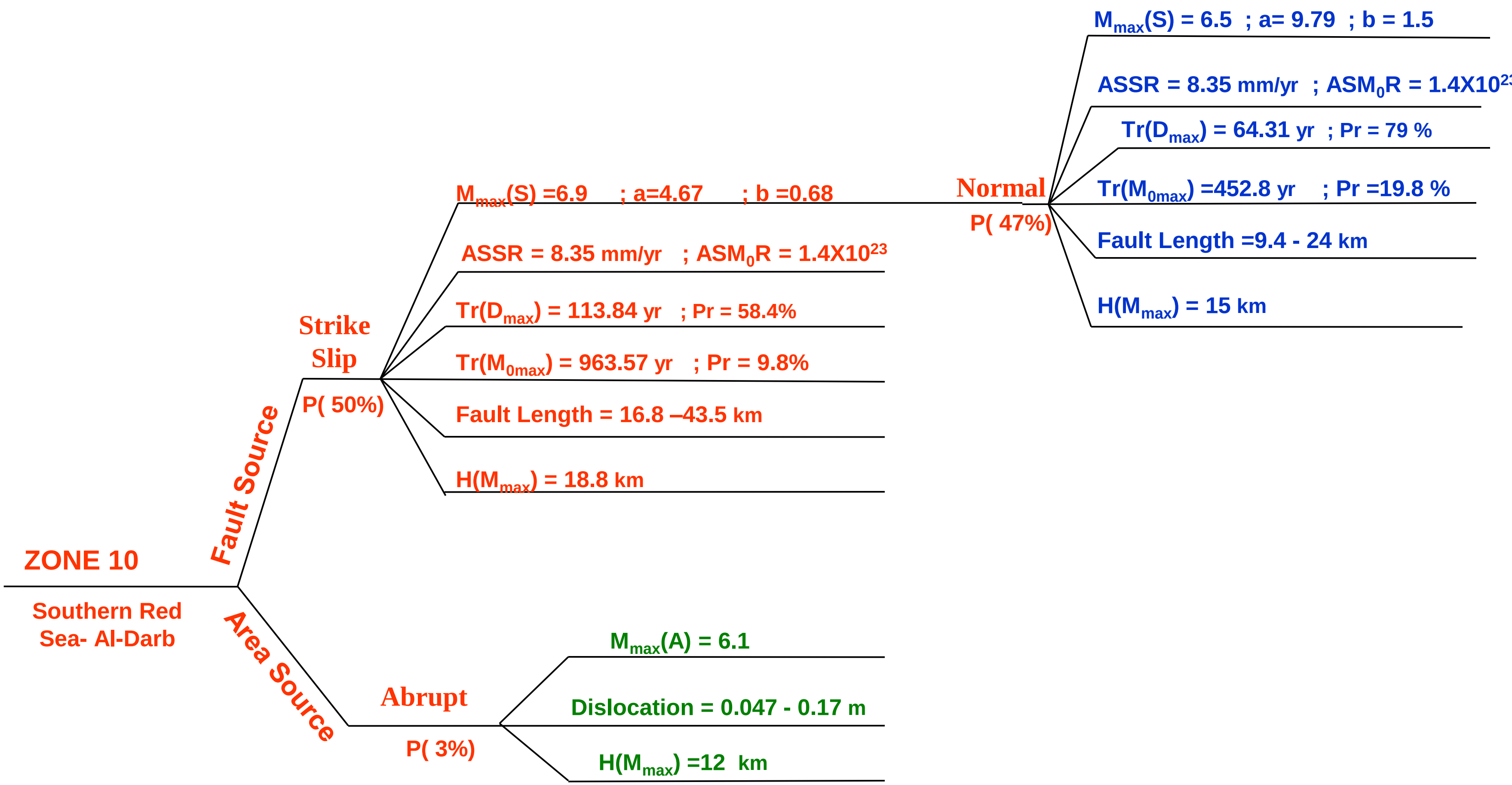
ASSR : Average seismicity slip rate in mm/yr
ASM_0R: Average seismic moment release rate (dyne-cm/yr)

P_r : Estimated probability of occurrence in 100 years
H(M_{max}) : Depth of crustal structure corresponding to M_{max}

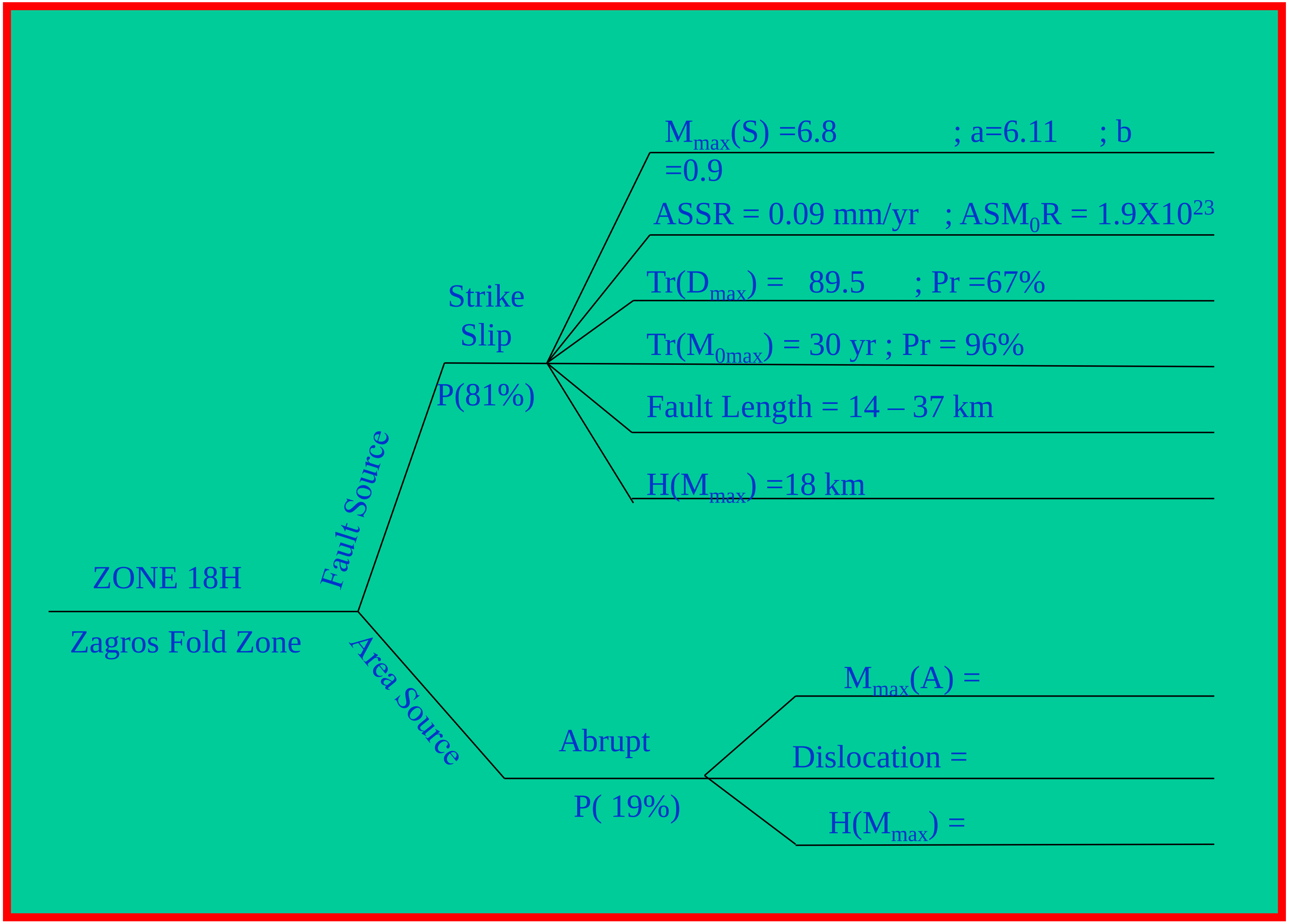
P : Assigned relative frequency of earthquake events for given tectonic source

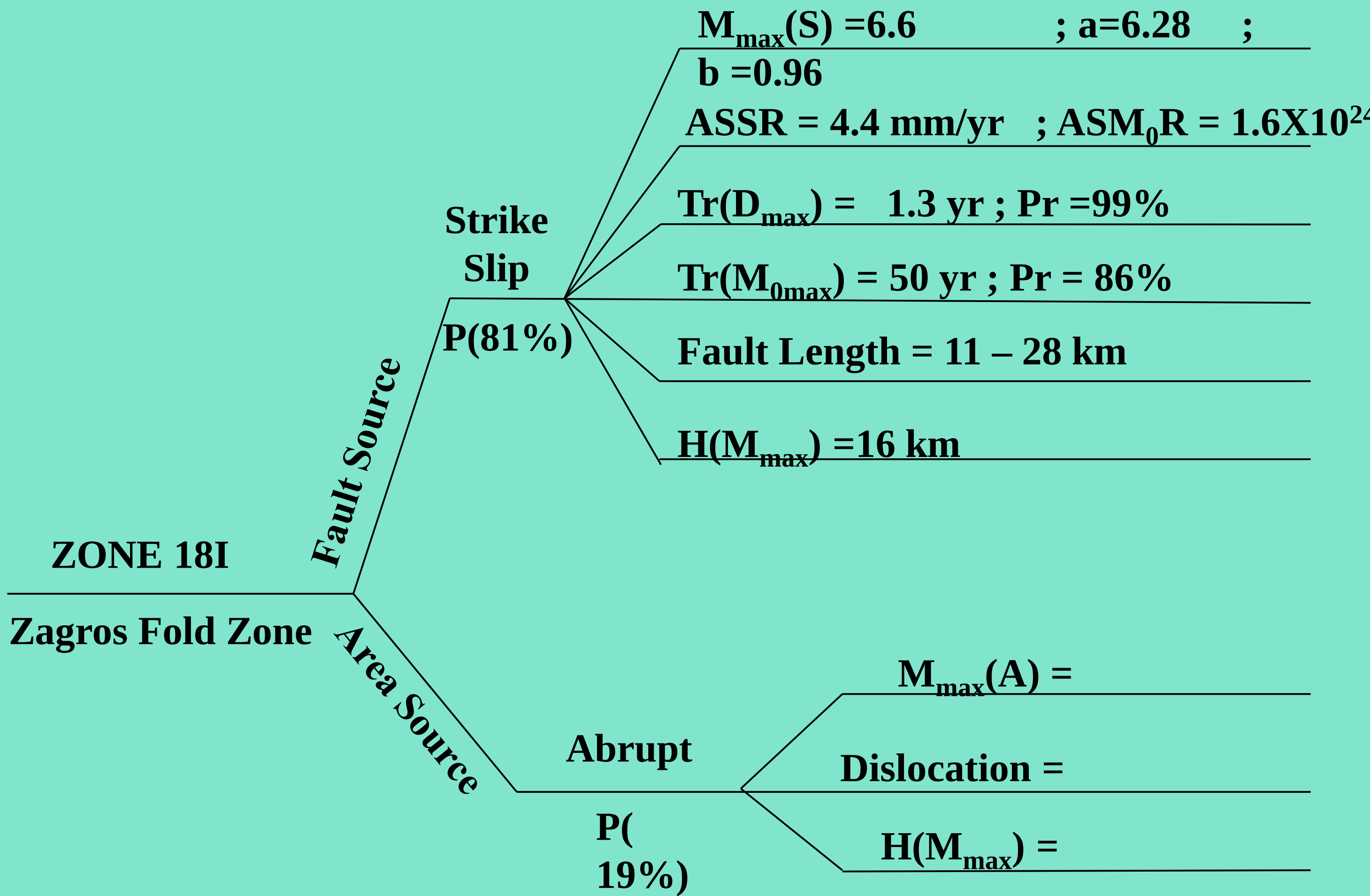
TrD_{max} : recurrence time in years of expected maximum dislocation corresponding to M_{max}

$TrMo_{max}$: repeat time, in years, of an earthquake population with a M_{max}

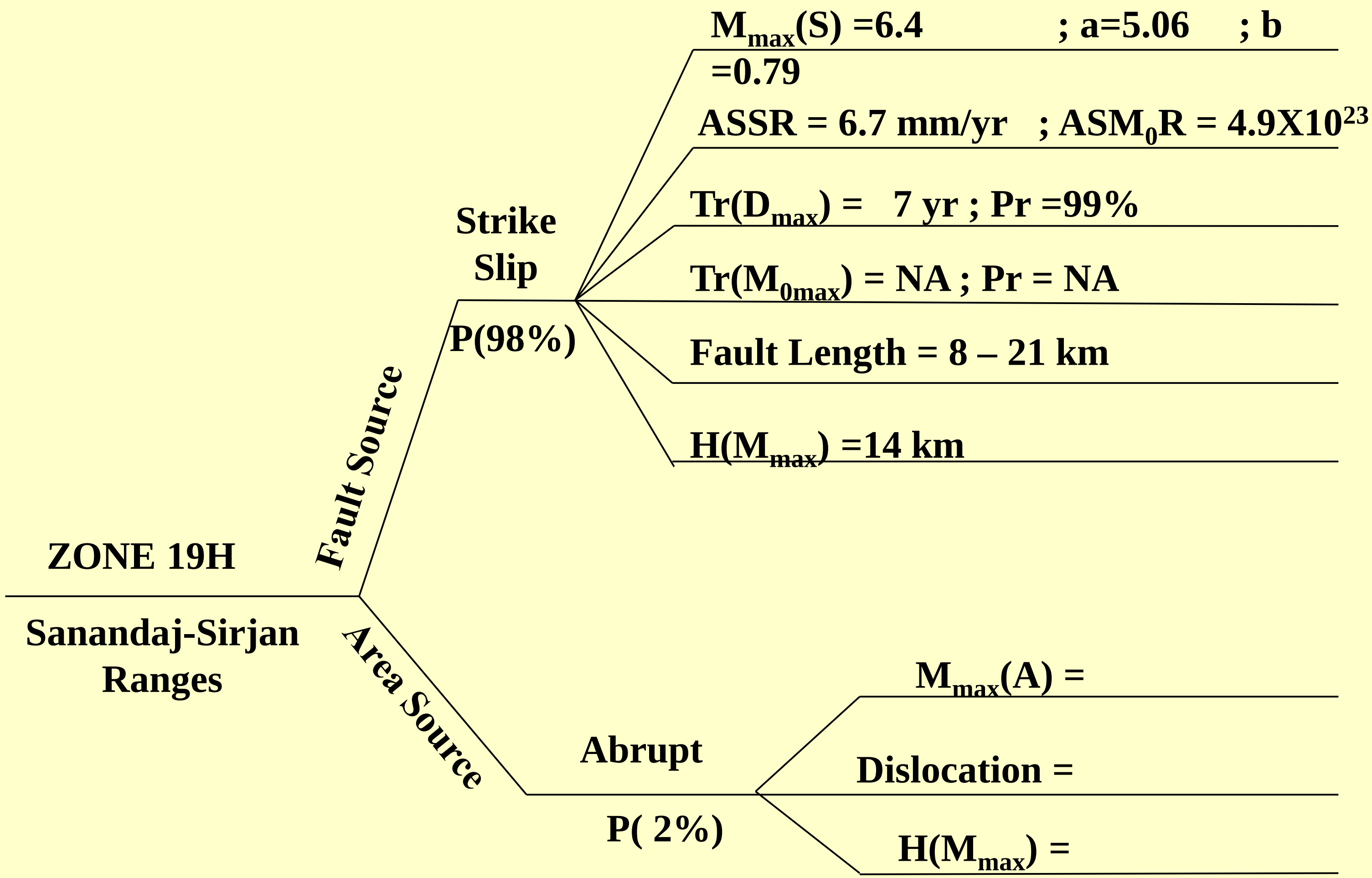


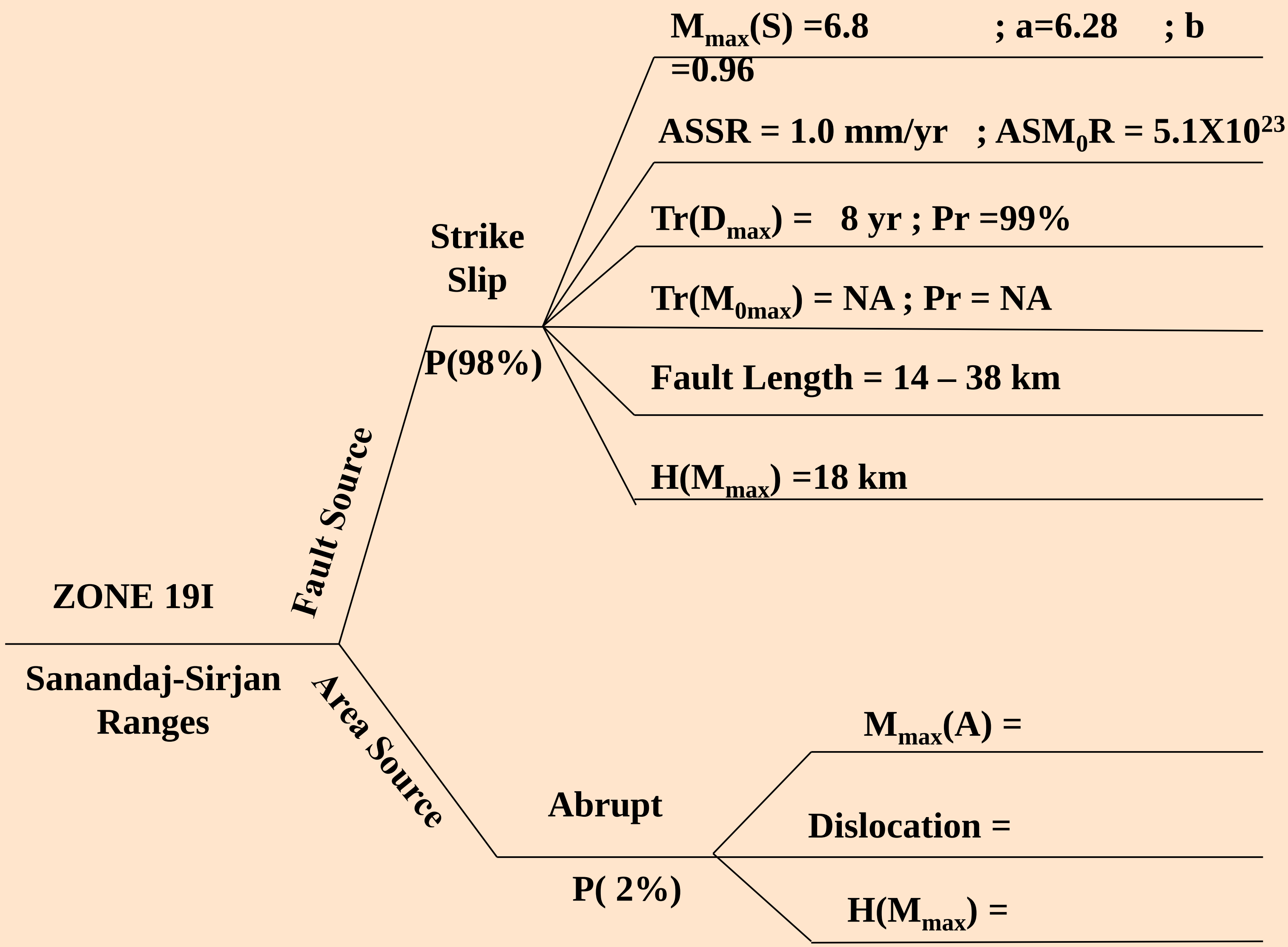
ZONE 10
Southern Red
Sea- Al-Darb
Fault Source
Area Source
Strike
Slip
P(50%)
$M_{max}(S)$ =6.9 ; a=4.67 ; b =0.68
ASSR = 8.35 mm/yr ; ASM_0R = 1.4X10^{23}
$Tr(D_{max})$ = 113.84 yr ; Pr = 58.4%
$Tr(M_{0max})$ = 963.57 yr ; Pr = 9.8%
Fault Length = 16.8 –43.5 km
$H(M_{max})$ = 18.8 km
Normal
P(47%)
$M_{max}(S)$ = 6.5 ; a= 9.79 ; b = 1.5
ASSR = 8.35 mm/yr ; ASM_0R = 1.4X10^{23}
$Tr(D_{max})$ = 64.31 yr ; Pr = 79 %
$Tr(M_{0max})$ =452.8 yr ; Pr =19.8 %
Fault Length =9.4 - 24 km
$H(M_{max})$ = 15 km
Abrupt
P(3%)
$M_{max}(A)$ = 6.1
Dislocation = 0.047 - 0.17 m
$H(M_{max})$ =12 km

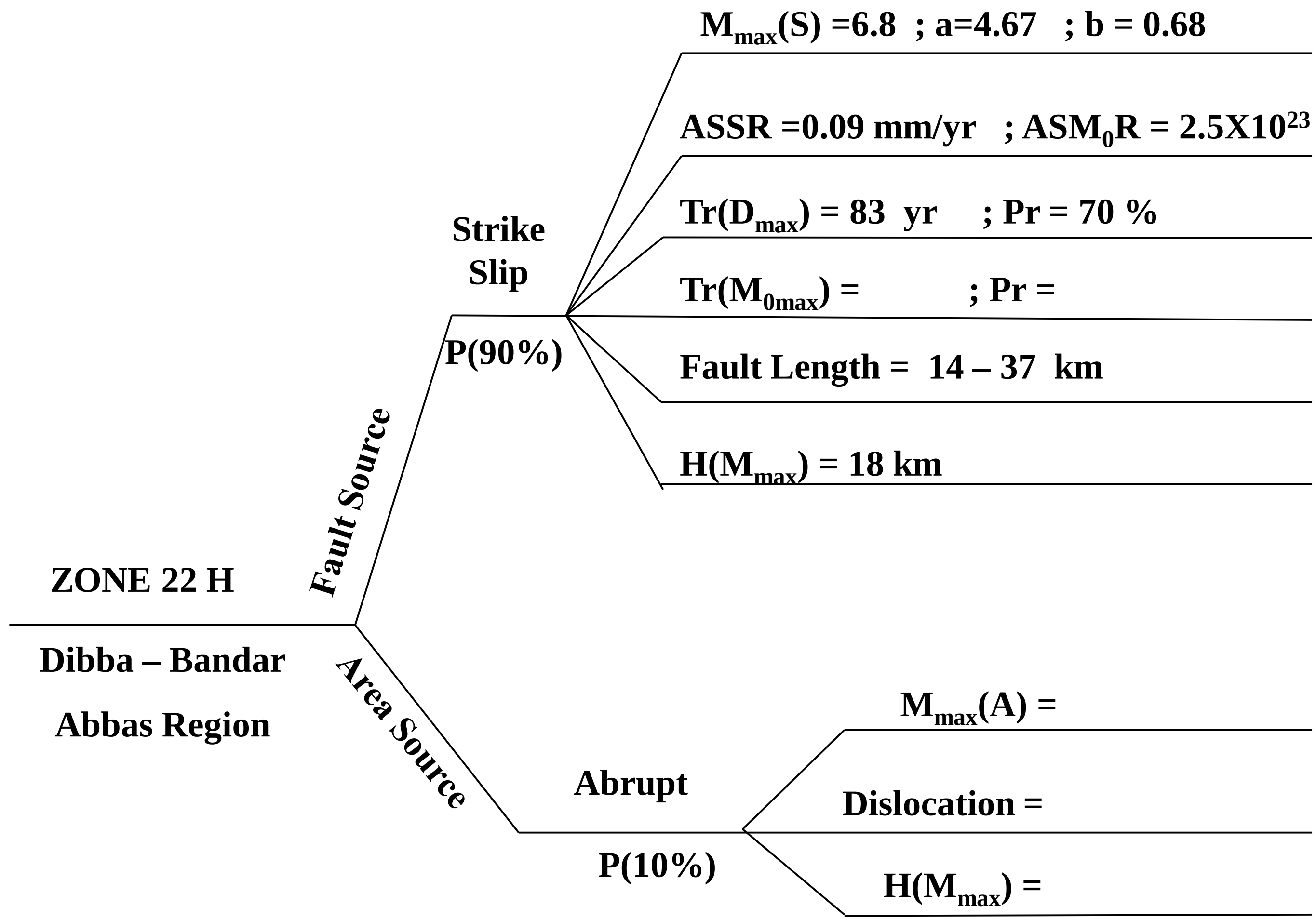

ZONE 18H
Zagros Fold Zone
Fault Source
Area Source
Strike
Slip
P(81%)
$M_{max}(S)$ =6.8 ; a=6.11 ; b =0.9
ASSR = 0.09 mm/yr ; $ASM_0R = 1.9X10^{23}$
$Tr(D_{max})$ = 89.5 ; Pr =67%
$Tr(M_{0max})$ = 30 yr ; Pr = 96%
Fault Length = 14 – 37 km
$H(M_{max})$ =18 km
Abrupt
P(19%)
$M_{max}(A)$ =
Dislocation =
$H(M_{max})$ =



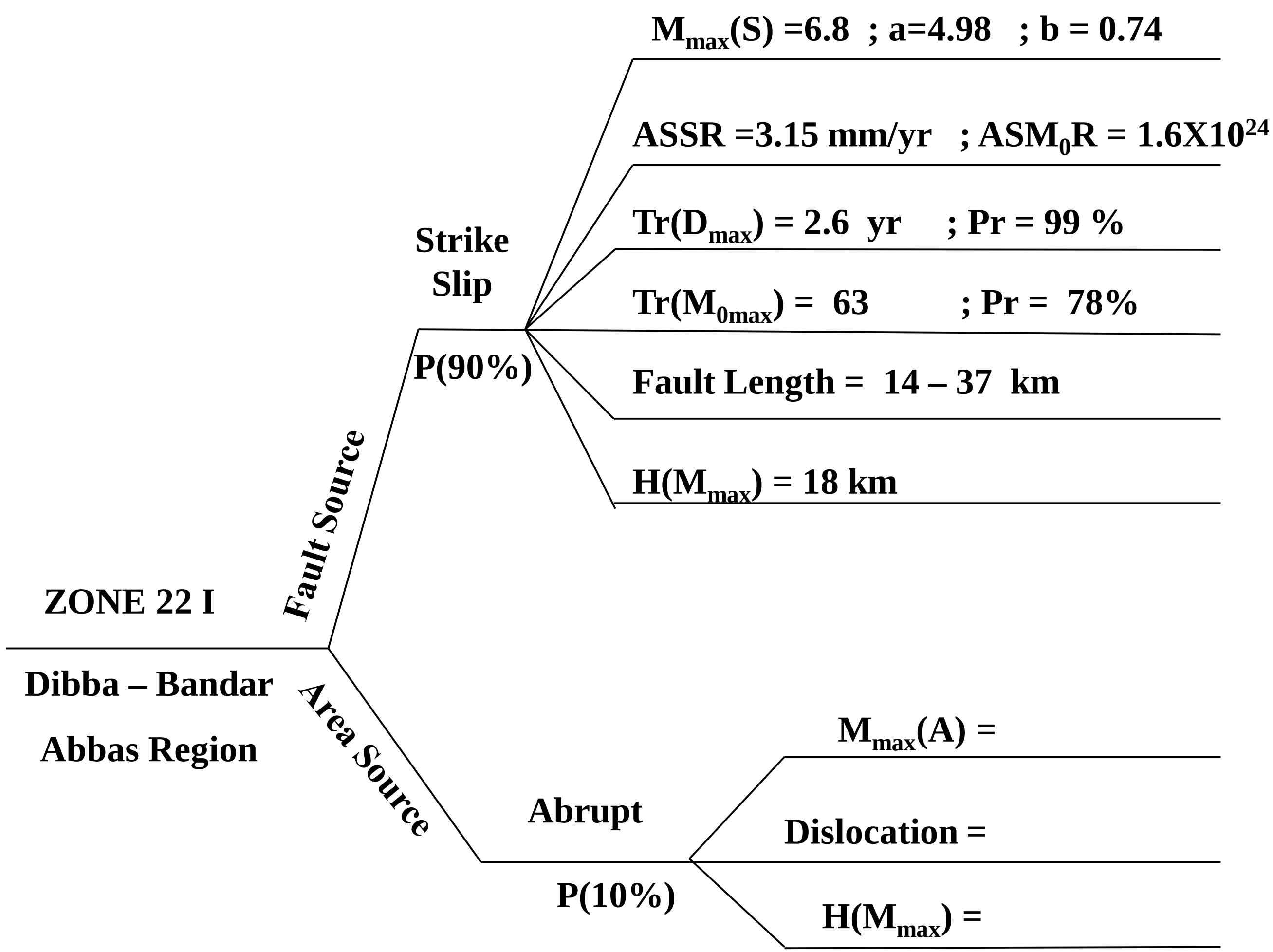
ZONE 18I
Zagros Fold Zone
Fault Source
Strike Slip
P(81%)
Mmax(S) =6.6 ; a=6.28 ; b =0.96
ASSR = 4.4 mm/yr ; ASM0R = 1.6X10^24
Tr(Dmax) = 1.3 yr ; Pr =99%
Tr(M0max) = 50 yr ; Pr = 86%
Fault Length = 11 – 28 km
H(Mmax) =16 km
Area Source
Abrupt
P(19%)
Mmax(A) =
Dislocation =
H(Mmax) =


ZONE 19H
Sanandaj-Sirjan Ranges
Fault Source
Strike Slip
P(98%)
M_{max}(S) =6.4 ; a=5.06 ; b =0.79
ASSR = 6.7 mm/yr ; ASM_0R = $4.9X10^{23}$
Tr(D_{max}) = 7 yr ; Pr =99%
Tr(M_{0max}) = NA ; Pr = NA
Fault Length = 8 – 21 km
H(M_{max}) =14 km
Area Source
Abrupt
P(2%)
M_{max}(A) =
Dislocation =
H(M_{max}) =

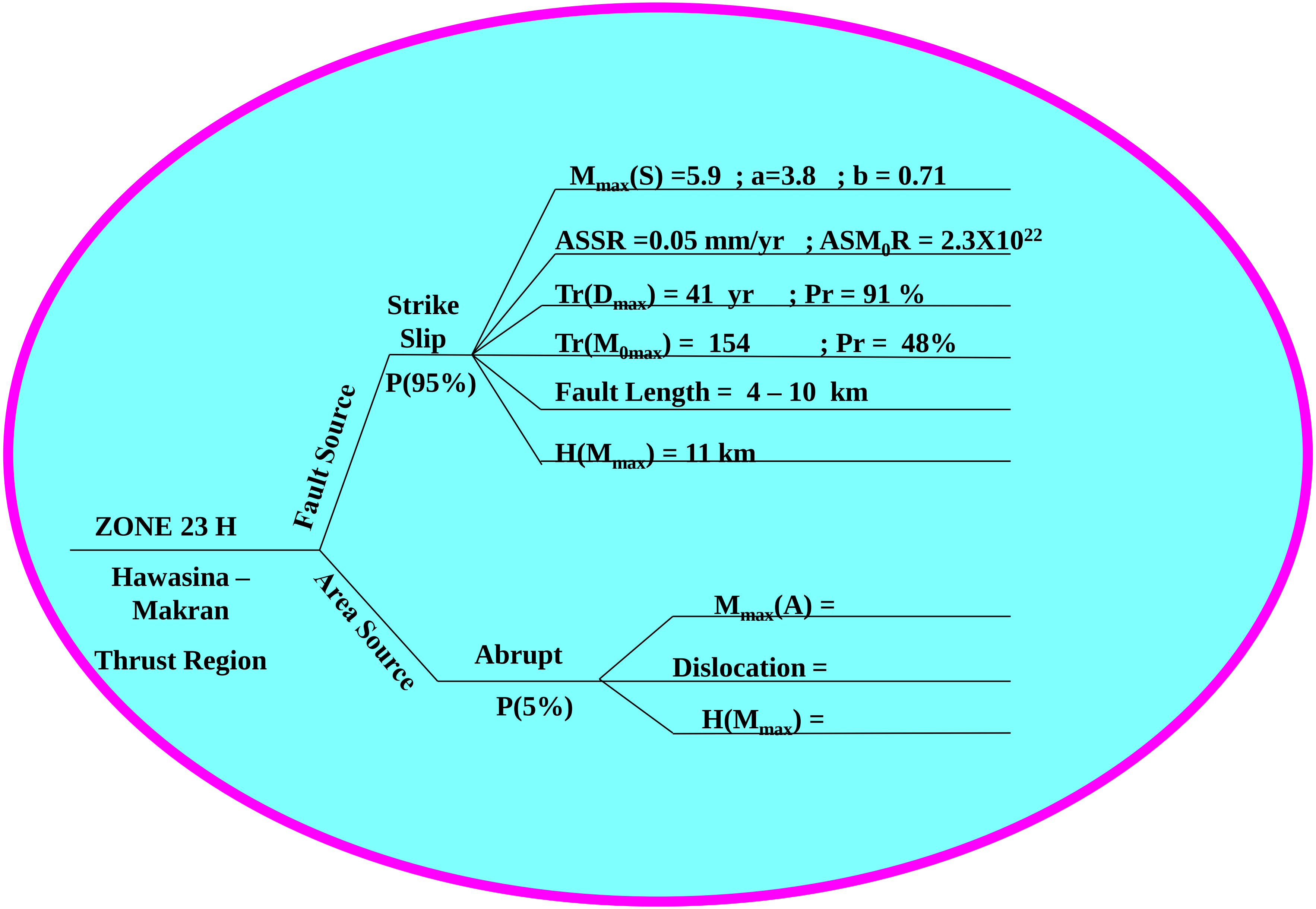

ZONE 19I
Sanandaj-Sirjan Ranges
Fault Source
Area Source
Strike Slip
P(98%)
M_{max}(S) =6.8 ; a=6.28 ; b =0.96
ASSR = 1.0 mm/yr ; ASM_0R = 5.1X10^{23}
Tr(D_{max}) = 8 yr ; Pr =99%
Tr(M_{0max}) = NA ; Pr = NA
Fault Length = 14 – 38 km
H(M_{max}) =18 km
Abrupt
P(2%)
M_{max}(A) =
Dislocation =
H(M_{max}) =



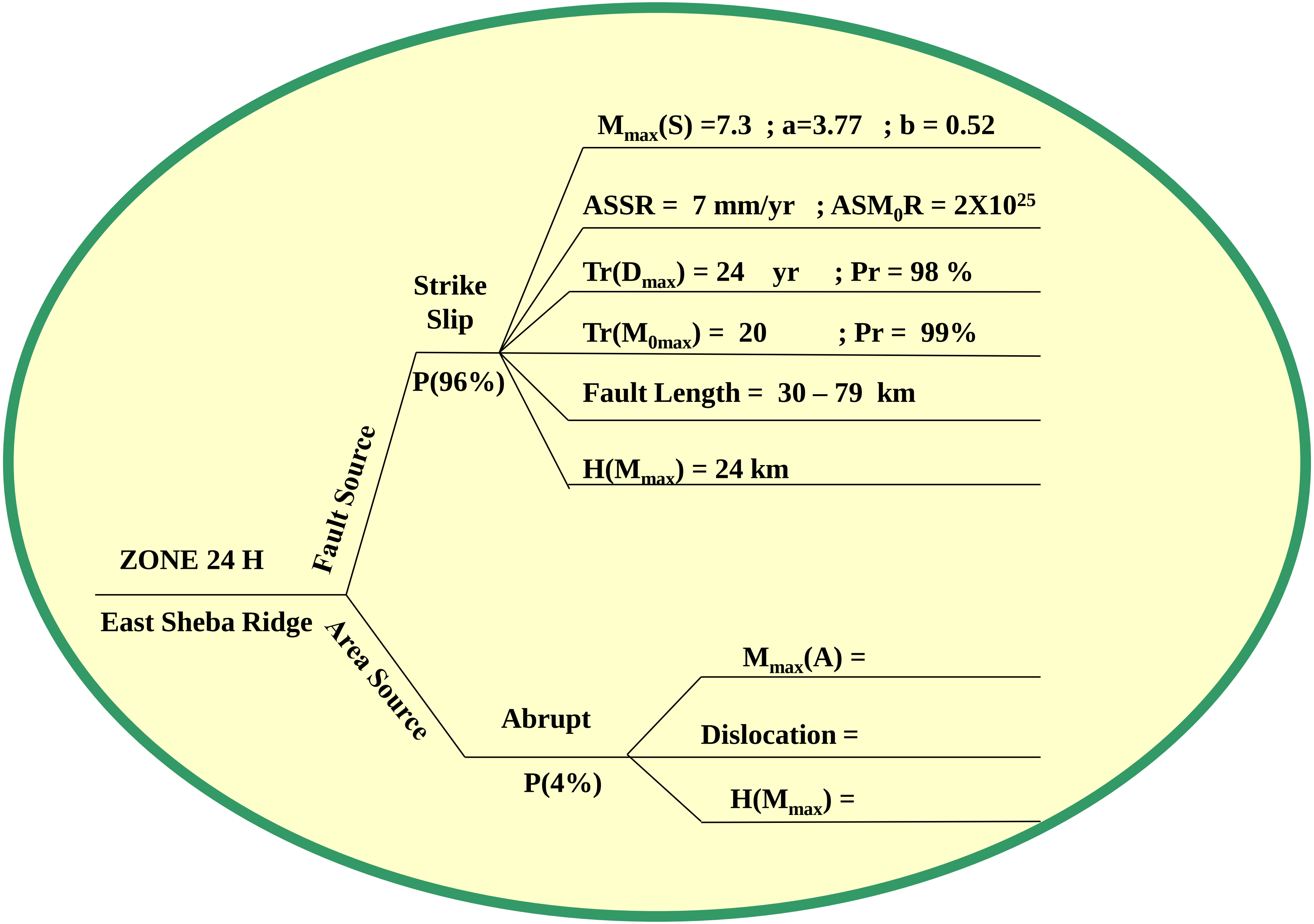
$M_{max}(S)$ =6.8 ; a=4.67 ; b = 0.68
ASSR =0.09 mm/yr ; ASM_0R = 2.5X10^{23}
$Tr(D_{max})$ = 83 yr ; Pr = 70 %
Strike Slip
$Tr(M_{0max})$ = ; Pr =
P(90%)
Fault Length = 14 – 37 km
Fault Source
$H(M_{max})$ = 18 km
ZONE 22 H
Dibba – Bandar Abbas Region
Area Source
$M_{max}(A)$ =
Abrupt
Dislocation =
P(10%)
$H(M_{max})$ =



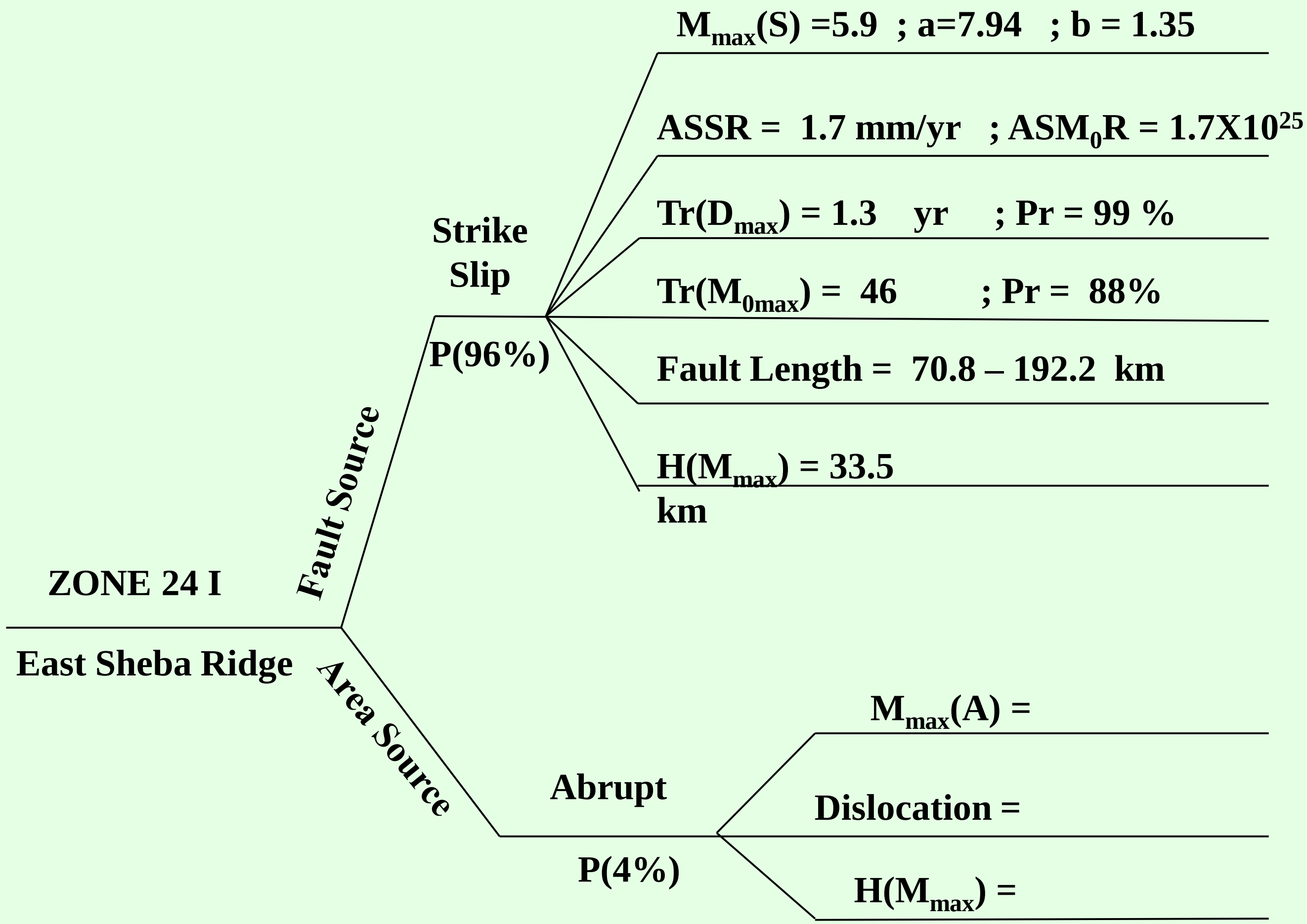
$M_{max}(S)$ =6.8 ; a=4.98 ; b = 0.74
ASSR =3.15 mm/yr ; ASM_0R = 1.6X10^{24}
$Tr(D_{max})$ = 2.6 yr ; Pr = 99 %
$Tr(M_{0max})$ = 63 ; Pr = 78%
Fault Length = 14 – 37 km
$H(M_{max})$ = 18 km
Strike
Slip
P(90%)
Fault Source
ZONE 22 I
Dibba – Bandar
Abbas Region
Area Source
Abrupt
P(10%)
$M_{max}(A)$ =
Dislocation =
$H(M_{max})$ =



ZONE 23 H
Hawasina – Makran
Thrust Region
Fault Source
Area Source
Strike Slip
P(95%)
$M_{max}(S)$ =5.9 ; a=3.8 ; b = 0.71
ASSR =0.05 mm/yr ; ASM_0R = $2.3X10^{22}$
$Tr(D_{max})$ = 41 yr ; Pr = 91 %
$Tr(M_{0max})$ = 154 ; Pr = 48%
Fault Length = 4 – 10 km
$H(M_{max})$ = 11 km
Abrupt
P(5%)
$M_{max}(A)$ =
Dislocation =
$H(M_{max})$ =

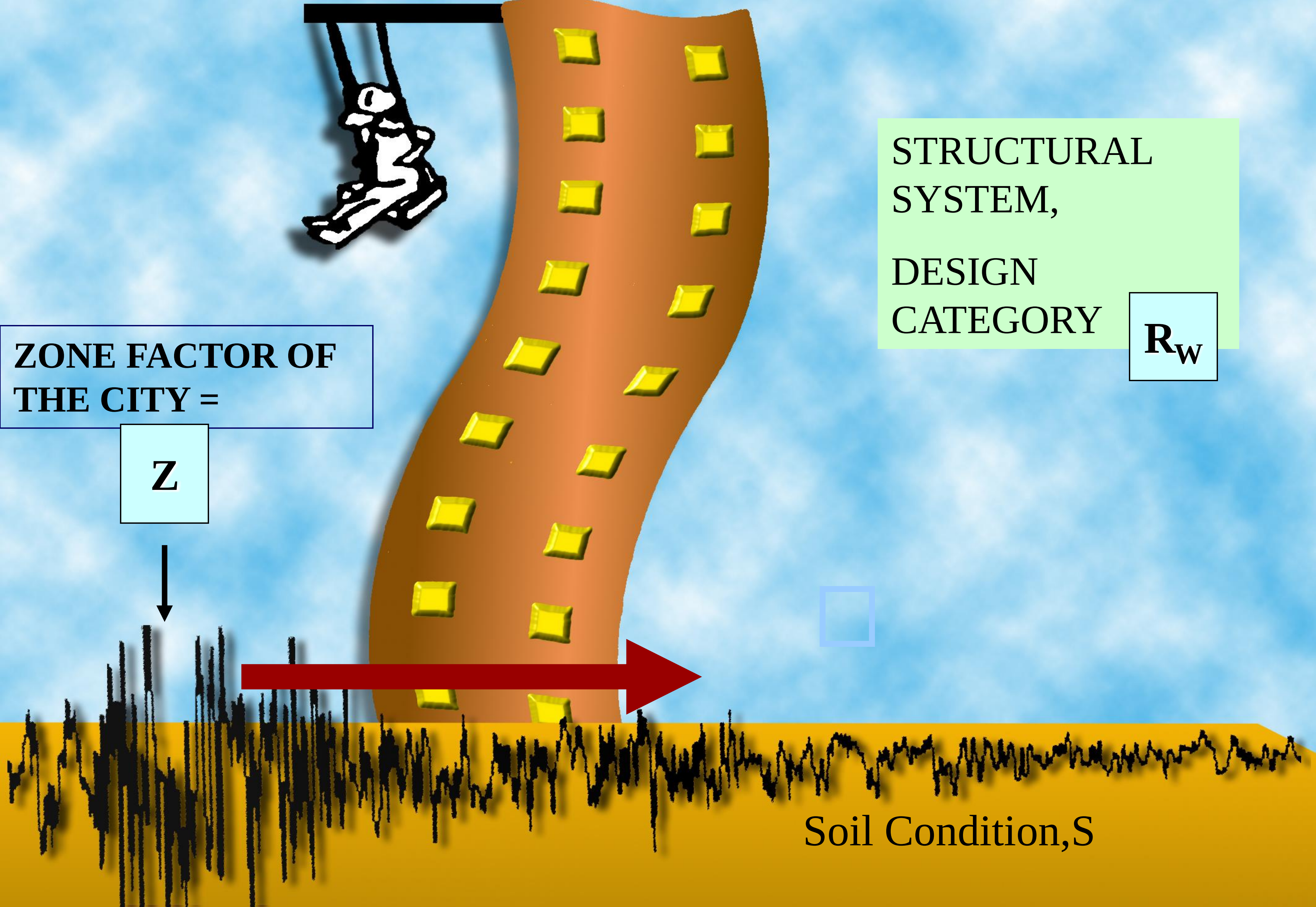


ZONE 24 H
East Sheba Ridge
Fault Source
Area Source
Strike Slip
P(96%)
$M_{max}(S)$ =7.3 ; a=3.77 ; b = 0.52
ASSR = 7 mm/yr ; $ASM_0R = 2X10^{25}$
$Tr(D_{max})$ = 24 yr ; Pr = 98 %
$Tr(M_{0max})$ = 20 ; Pr = 99%
Fault Length = 30 – 79 km
$H(M_{max})$ = 24 km
Abrupt
P(4%)
$M_{max}(A)$ =
Dislocation =
$H(M_{max})$ =



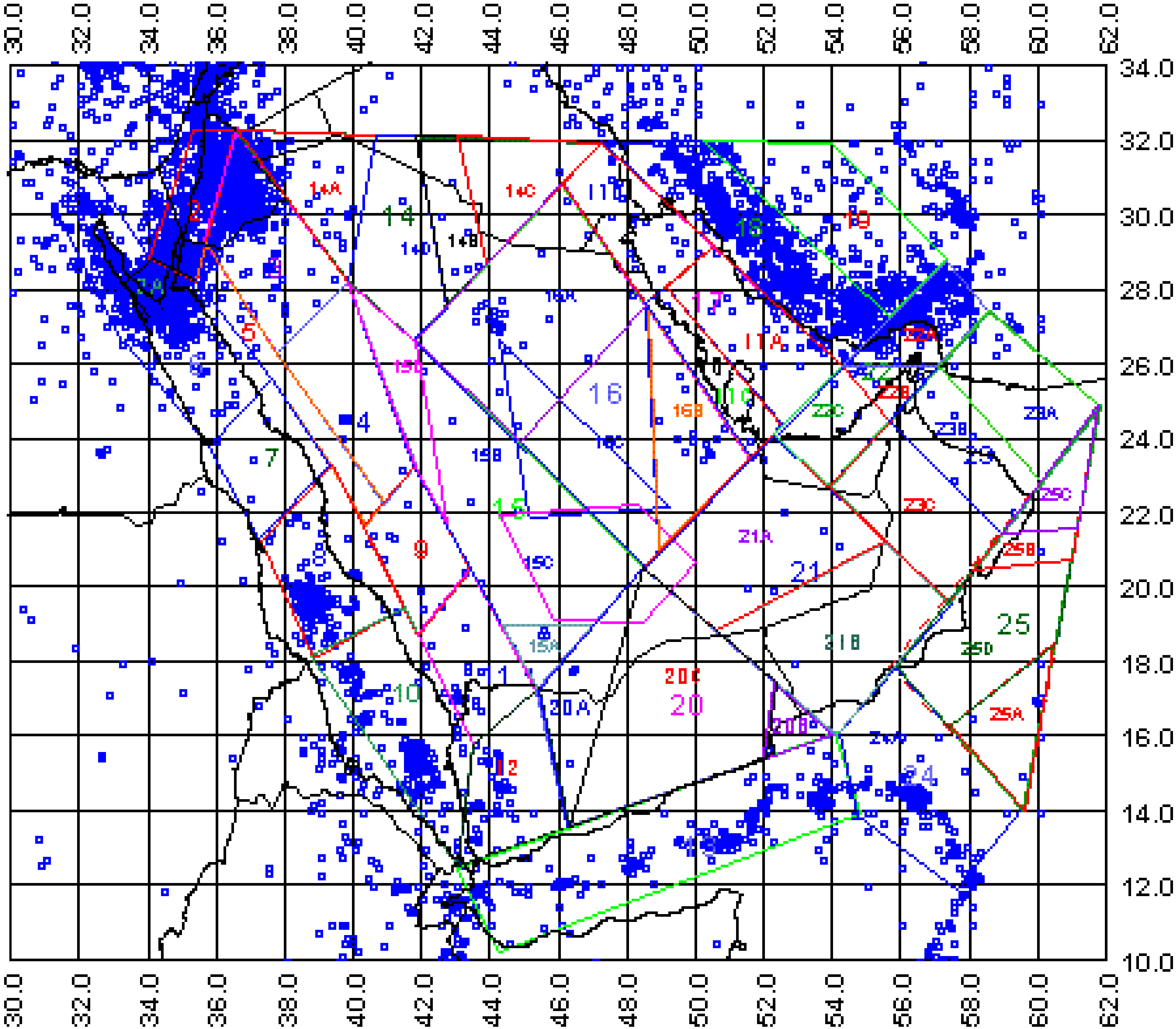
ZONE 24 I
East Sheba Ridge
Fault Source
Area Source
Strike Slip
P(96%)
M_{max}(S) =5.9 ; a=7.94 ; b = 1.35
ASSR = 1.7 mm/yr ; ASM_0R = 1.7X10^{25}
Tr(D_{max}) = 1.3 yr ; Pr = 99 %
Tr(M_{0max}) = 46 ; Pr = 88%
Fault Length = 70.8 – 192.2 km
H(M_{max}) = 33.5 km
Abrupt
P(4%)
M_{max}(A) =
Dislocation =
H(M_{max}) =

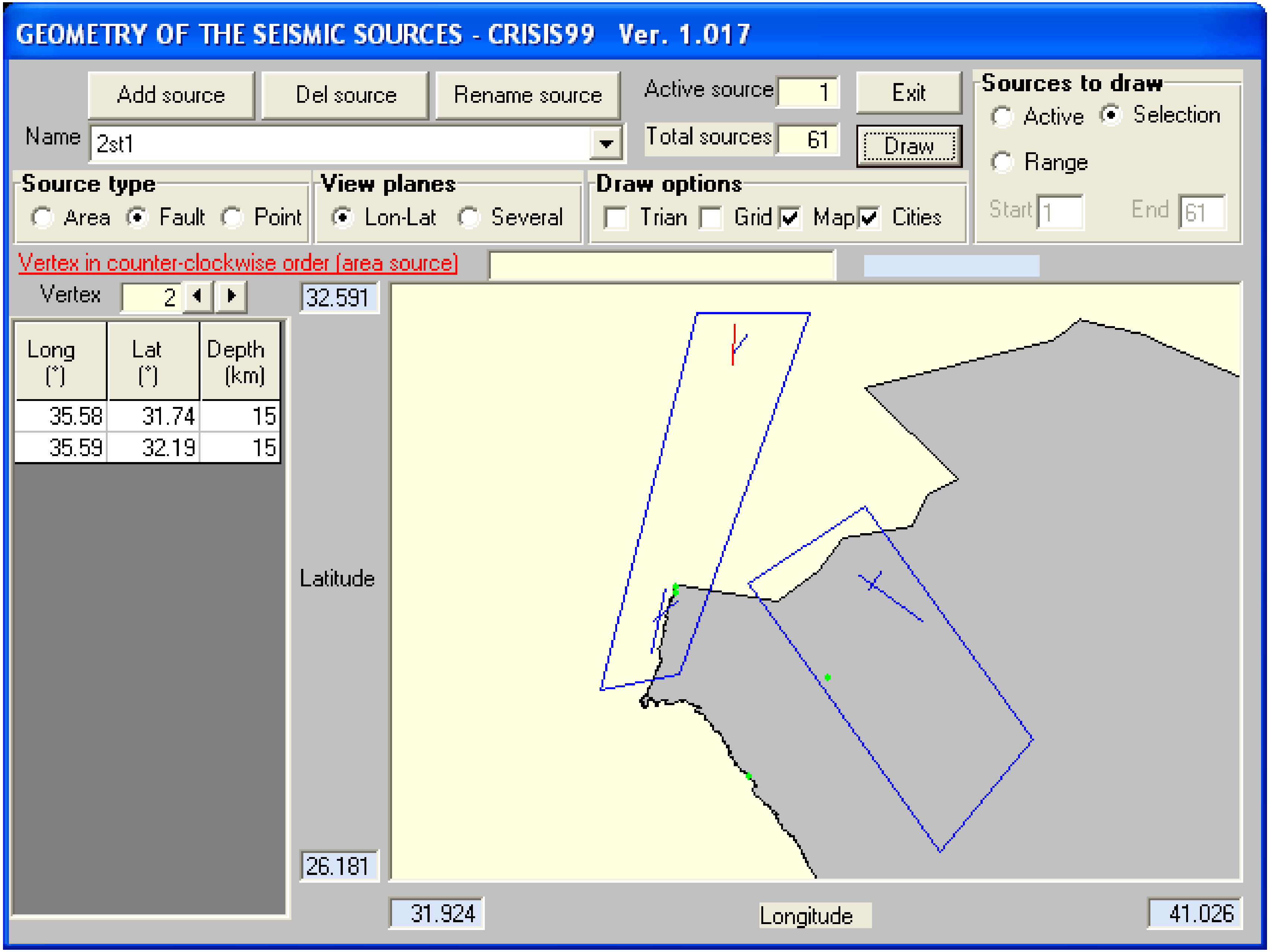
COMPARISON PARAMETERS

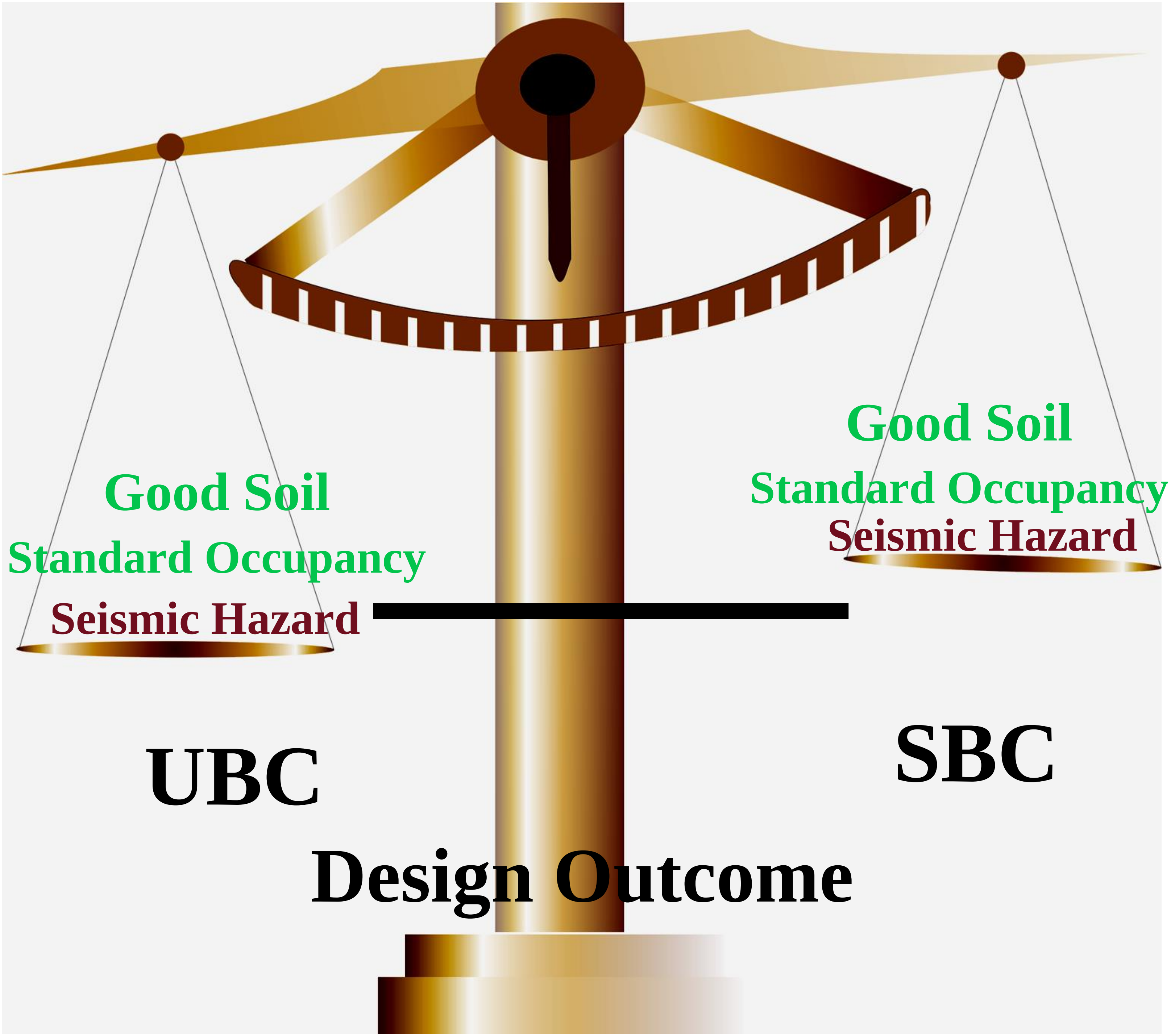


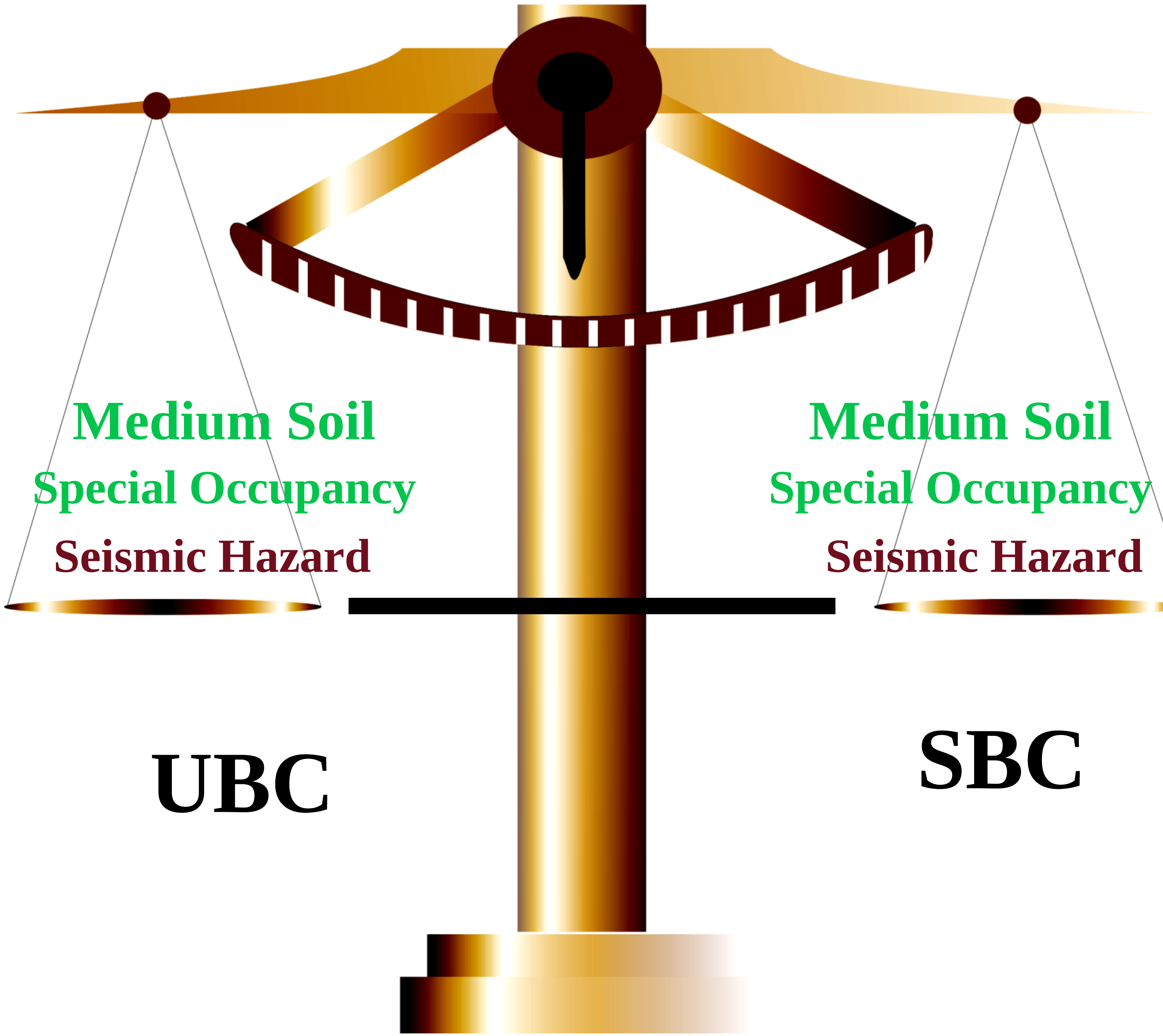
Z-Factor

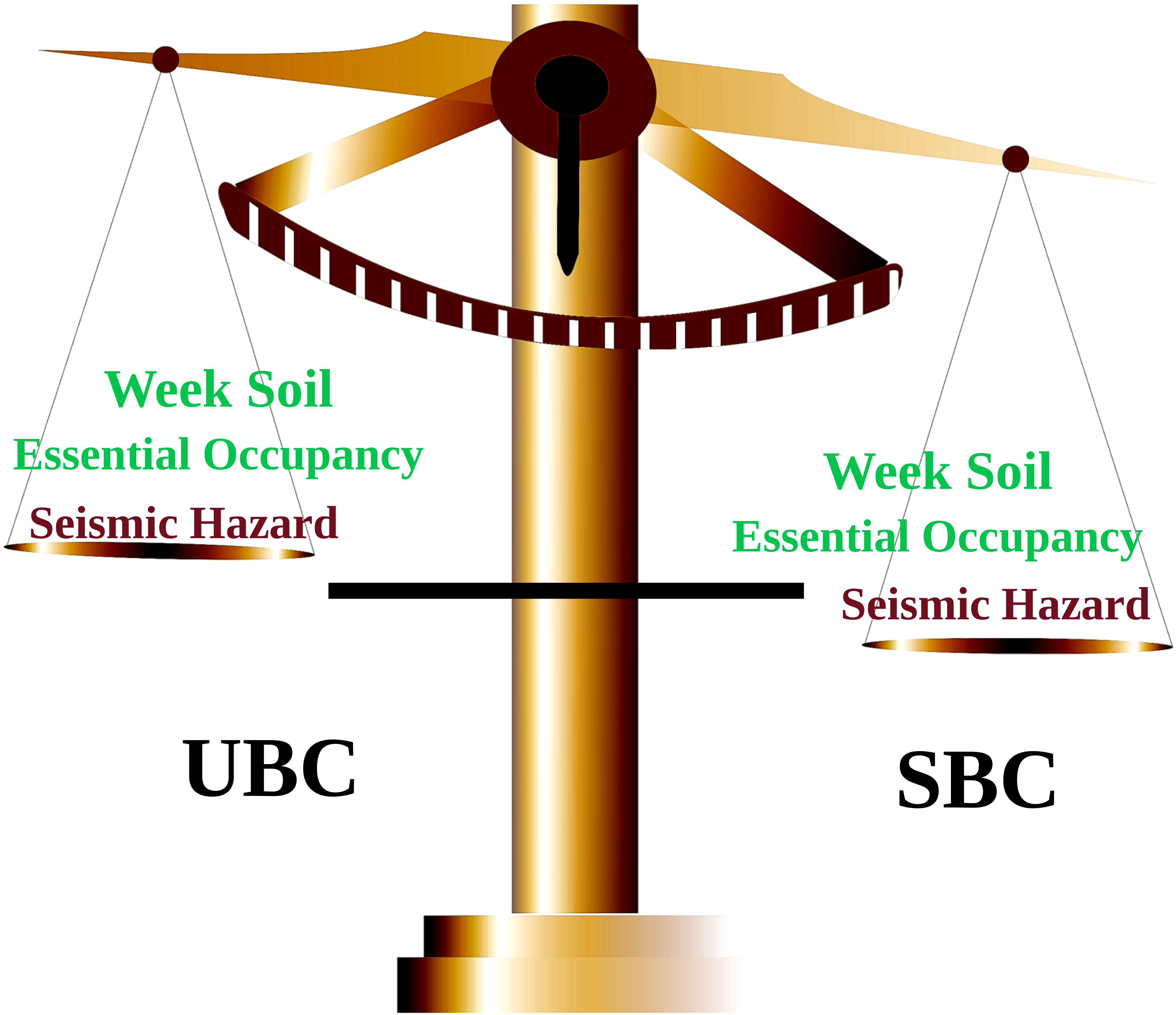
Zone	1	2A	2B
Z	0.075	0.15	0.2


30.0
32.0
34.0
36.0
38.0
40.0
42.0
44.0
46.0
48.0
50.0
52.0
54.0
56.0
58.0
60.0
62.0
34.0
32.0
30.0
28.0
26.0
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
14A
14C
11C
14
14B
14D
18
19
15A
17
11A
22A
16
15B
11B
22C
22B
23A
23B
24
7
15B
16C
23
15
23C
25C
21A
21
25B
20
9
15C
25
31B
25D
15A
20C
20
10
20A
20B
24A
25A
12
24


GEOMETRY OF THE SEISMIC SOURCES - CRISIS99 Ver. 1.017
Add source
Del source
Rename source
Active source 1
Exit
Name 2st1
Total sources 61
Draw
Sources to draw
Active
Selection
Range
Start 1
End 61
Source type
Area Fault Point
View planes
Lon-Lat Several
Draw options
Trian Grid Map Cities
Vertex in counter-clockwise order (area source)
Vertex 2
Long (°)
Lat (°)
Depth (km)
35.58 31.74 15
35.59 32.19 15
32.591
Latitude
26.181
31.924
Longitude
41.026


Good Soil
Standard Occupancy
Seismic Hazard
Good Soil
Standard Occupancy
Seismic Hazard
UBC
SBC
Design Outcome


Medium Soil
Special Occupancy
Seismic Hazard
Medium Soil
Special Occupancy
Seismic Hazard
UBC
SBC



Week Soil
Essential Occupancy
Seismic Hazard
Week Soil
Essential Occupancy
Seismic Hazard
UBC
SBC