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A Brief on Geology and Seismicity of Safita Area





Fig. 3: Outcrop of the basaltic dike on which the tower is founded



Fig. 4: Close up of the fractured, weathered and partially altered basaltic dike



Fig.5: Southwest corner of the southern wall of the tower showing stone offset with amplitude increasing upward.

Geologically, Safita is situated within the Coastal Range (CR) which is a monocline whose western flank dips gently at 15 degrees westwards while it is bounded in the East by the S-N trending Syrian-Lebanese fault (SLF) which is considered as the northernmost segment of the Dead Sea faulting system. The CR and the SLF are truncated far north by a mighty faulting system called East-Anatolian Faulting System (EAF). From historical and instrumental seismic point of view, SLF and EAF are very seismically active (Fig. 1; Tables 1 & 2).

Safita as a town lies on the Upper Cenomanian Hannafieh Formation which consists mainly of limestones, marly limestones and marls. The formation is intruded by many Pliocene basaltic dikes (Fig 2). Geological and seismological field investigations carried out during the days of the workshop revealed that the Safita famous tower is directly built on southwestern-most end of a 10-kmlong Pliocene basaltic dike trending NE-SW. The tower basaltic foundation is severely fractured, weathered and partially altered (Fig 3 & 4). The tower itself shows evidence of seismic damage represented by seismic offsets of the building stones, specially on the southern wall, increasing upward the tower (Fig 5).

Available data sets show that the Safita area has experienced several strong shocks in the historical period Table 1). Fig. 11 shows localities affected by historical earthquakes in eastern and northern Syria; evidence of seismic effect has been recorded in Safita : for example, the earthquake of 20 May 1202 (macroseismic magnitude : 7.6), of 25 November 1759 (magnitude : 7.4), or 13 August 1822 (magnitude : 7). From the beginning of the XXth century, a relative seismic quiescence prevails (Fig. 12 & 13). According to recent monitoring data provided by the Syrian General Establishment of Geology and Mineral Resources (Table 2), no significant seismic event has occurred in the region from May 1995 to December 1999.

The offsets observed in the northern

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Fig.6 & 7 : Fissures of the stones at the lower northern part of the western facade.



Fig. 8: Cracks in the dome of the apse of the church.



Fig. 9: Cracks (E-W extension) at the junction between the nave of the church and the western wall.



Fig. 10: Details for offsetting of the northern wall taken from inside the northwestern arch of the defense slot (2nd floor).

The offsets observed in the northern and southern walls (Fig. 5) and the cracks in the apse and the western part of the nave of the church suggest that the western and eastern walls have a tendency to fall apart from the center of the monument. The cause of this falling apart could be a combination of seismic loading and of the shape of the bedrock on which the tower is seating. Subsidence of the foundations of the edifice does not appear alone as a likely cause of the observed damage. Nevertheless the numerous sliding of heavy stone blocks with respect to each other is a clear evidence supporting the cumulative action of seismic loading. If the above interpretations are correct, attention should be paid to suitable reinforcement of the foundation and the monument itself in order to withstand the action of the coming earthquakes. Youssef Radwan & Jean Bonnin, 3-10 Sep 2000.

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Parametric Catalogue of large historical earthquakes in and around Syria

No.	Date	Latitude (°N)	Longitude (°E)	Major Affected Localities	Maximum Intensity (10) (EMS-92)	Focal Depth (km)	Macroseismie Magnitude (M)
011	37 AD	36.00	36.30	Antioch, Dafneh	VII-VIII	15	6.2
013	53	36.20	36.50	Antioch, Afamia, Manbei, Lattakia	Vill	30	6.6
022	303/304	33.80	34.30	Saida, Sur, Syria	VIII-IX	20	7.1
030	494	35.80	36.30	Antioch, Tripoli, Lattakia	VII-VIII	25	6.5 . gianos
032	502.08.22	33.00	34.80	Akka Sur, Saida, Beirut, Safad	VIII-IX	30	7.2
036	\$31/534	35.50	37.20	Area between Aleppo and Homs	VIII	15	6.5 Acche Same
017	551.07.09	34.00	35.50	Cities of Lebanese coast. Arwad	IX-X ·	28	7.3 292,254
040	565-571	36.00	36.20	Antioch, Seleucca, Kilikia, Anazrabo	VII-VIII	30	6.0 Ale
049	747.01.18	32.50	35,60	M. Tabor, Baalbak, Bosra, Nawa, Balqa, Al-Quds, Beit Qubayeli, Tabaryya, Damascus, Daraa	IX	25	7.2
056	847 11 24	34.40	36.30	In and around Damasous, Antioch, Al-Mosel	IX	35	7.5
058	859.12.30 - 860.01.29	35.70	36,40	Antioch, Lattakia, Jableh, Homs, Palmyra, Tarsus, Balis, Damuscus, Adana, Ar-Ragga	VIII-IX	33	7.4
065	991.04.05	33 70	36.40	Baalbak, Damascus	IX	22	7.1
070	1063.07.30 -08.27	34.40	36.20	Tripoli, Lattakin, Akka, Sur	VIII	32	6,9
075-0	1114 11	37.30	38.50	Maskanch, Maraash, Samsat, Orfa,	VIII-IX	40	7.4
075-b	1114.11	37.30	36.50	Harran	1X	40	7.7
082	1152 09 27	32.60	36 70	Bosra Hauran Syria	VIII	12	5.8
083-3	1157.04.02 - 04	35.50	36.50	Shaizar, Hama, Kafer Tab, Aleppo	VII	22	6.0
083.h	1157 07 13	35.20	36.60	Hama Afamia Kafer Tah Homs, Tayma	VUI	25	6.6
083-c	1157,08,12	35.40	36.60	Shaizar, Kafar Tab, Afamia, Hama, Arqa, Aleppo, Homs, Lattakia, Tripoli, Antioch, Oalaat Al-Hosn, M, Annooman	IX-X	15	7.4
084	1170.06.29	34,80	36,40	Damascus, Homs, Hama, Lattakia, Baalbak, Shaizar, Barin, Aleppo	IX	35	7.7
086	1202.05.20	34.10	36.10	Mount Lebanon, Baalbak, Sur, Beit Jin, Banyas, Nablus, Al-Samyra, Damascus, Safita, Akka, Tripoli, Hauran, Beirut, Homs, Tartus	IX	30	7.6

Table 1 continued on the next page, From: Final Report of the Research project: " Seismic Data for siting and Site Re-Validation of Nuclear Facilities. AECS & IREA 1998, Damascus, A tomic Energy Commission of Syria

	No.	Date	Latitude (°N)	Longitude (°E)	Major Affected Localities	Maximum Intensity (10) (EMS-92)	Focal Depth (km)	Macro Magni (M)
1	100	1344.01.02	36.70	37.40	Al-Rawendan, Manbei, Aleppo	VШ	30	6.8
	104	1404.02.20	35,70	36.20	Blatues, Bkas, West of Aleppo, Qalaat Al-Margeb, Tripoli, Lattakia, Jableh	VIII-1X	30	7.4
-\$	J07	1408.12.29	35,80	36.10	Shugr, Bkas, Blatnes, Lattakia, Jableh, Ardioch, Syrian coast	ix	25	7.4
	115	1568.10.10	35,50	35.50	Lattakia, Famagusta	VIII	12	6.0
	124	1626.01.21	36.50	37.10	Aleppo, Gaziantab, Hama	1X	20	7.3
	129	1666.09.22	37.00	43.00	Al-Mousel, Sinjar, Sharqat	IX	35	6.9
-	134	1705. 11.24	33,70	36,60	Yabroud, Al-Qastal, Damascus, Tripoli	VIII	35	6.9
	138	1726.04.15	36.30	36.60	Jum, Aleppo	VUI	15	6.1
	139	1738.09,25	36.70	36.50	Iskenderun, Bellen Bass, Antioch, Jabal Al-Amanus, Aleppo	VIII	10	6.2
	143	1759.10,30	33.10	35.60	Ai-Qunaytra, Safad, Akka, An-Nasra, Sidon, Saasaa	VIII-IX	20	6.6
*	144	1759.11.25	33.70	35.90	Baalbak, Zabadani, Ras Baalbak, Al- Quruytra, Damascus, Beirut, Saida, Safad, Sur, Tripoli, Homs, Hama, An- Nasra, Lattakia, Al-Ouds, Gaza, Antioch	IX	30	7.4
	152	1796.04.26	35.30	36,20	Qalaat Al-Marqeb, Al-Qadmeus, Nahr Al-Kabir, Jableh, Bkas, Luttakia	VIII-IX	20	6.8
+	157	1822.08.13	36.10	36.75	Jisr Ash'Shoughour, Qascir, Aleppo, Darkoush, Antioch, Iskenderun, Idleb, Ketless, Armanaz, Sarmada, Lattakia, Homs, Hama, Maraash, Bennesh, R. Hamadam, Bennesh, M. Missrin	Child (2MS-87) Change (Marcon	18	7.0
1	171	1872.04.03	36.20	36.50	Harem, Armanaz, Lake of Al-Amq, Antioch, Aleppo, Suaidiya, Izaz, Idleb, Istendorum	VIII-IX	10	5.9

From: Final Report of the Research project: "Seismic Data for Siting and Site Revalidation of Nuclear Facilities. AECS & IREA, 1998, Damascus, Atomic Energy Commission of Syria.

Table: 1

38 37 36 35 34 33 33 -Compiled Catalogue 32 L 36 32 an 42 38 32 34 36 36 30 40 40 42 Fig. 13: Seismic exents occured during the period 1980-1982 according to the TUR, SBI, NEIC, Compiled Catalogue, From: Report of the researd, project " Seismic Data for Siting and Site Re-validation of Nuclear Facilities "AECS & IAEA, 1998, Dama-Scus, Atomic Energy Commission of Syria.

SYRIAN ARAB REPUBLIC MINISTRY OF PETROLEUM AND MINERAL RESOURCES THE GENERAL EST OF GEOLOGY & MIN . RESOURCES P.O.BOX :7645 telegram:geomineral TEL:445426-4447755-4450507 TELEX :4411528 G.E.O.SY FAX : 4423684 DAMASCUS					الجموورية العربية السورية وزارة النغط والثروة المعدنية مديرية الرمد الزلزالي ص- 2017 - برفيا" :جيوميتبرال 26-2017 - برفيا" :جيوميتبرال 26-2017 - برفيات 22 / 20-02 مانف: 2019 - 22 / 2019 فاكس : 2019 92 دمشق دمشق				
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Table 2 Continued

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