

1 Tsunami heights and limits in 1945 along the 2 Makran coast estimated from testimony 3 gathered seven decades later in Gwadar, Pasni 4 and Ormara

5 Hira Ashfaq Lodhi¹, Shoaib Ahmed², Haider Hasan²

6 ¹Department of Physics, NED University of Engineering & Technology, Karachi, 75270, Pakistan

7 ² Department of Civil Engineering, NED University of Engineering & Technology, Karachi, 75270, Pakistan

8 *Correspondence to:* Hira Ashfaq Lodhi (hiralodi@neduet.edu.pk)

9 **Abstract.**

10 The towns of Pasni and Ormara were the most severely affected by the 1945 Makran tsunami. The water inundated almost a
11 kilometre at Pasni, engulfing 80% huts of the town while at Ormara tsunami inundated two and a half kilometres washing
12 away 60% of the huts. The plate boundary between the Arabian plate and Eurasian plate is marked by Makran Subduction
13 Zone (MSZ). This Makran subduction zone in November 1945 was the source of a great earthquake (8.1 Mw) and an
14 associated tsunami. Estimated death tolls, waves arrival times, the extent of inundation and runup remained vague. We
15 summarize observations of tsunami through newspaper items, eye witness accounts and archival documents. The information
16 gathered is reviewed and quantized where possible to get the inundation parameters in specific and impact in general along
17 the Makran coast. The quantization of runup and inundation extents is based on a field survey or old maps.

18 **1 Introduction**

19 The recent tsunami events of 2004 Indian Ocean (Sumatra) tsunami, 2010 (Chile) and 2011 (Tohoku) Pacific Ocean tsunami
20 have highlighted the vulnerability of coastal areas and coastal communities to such events. Credible vulnerability assessment
21 of a coast depends upon reliable geoscientific data on past tsunami events. The data from past events is crucial as it forms the
22 basis for numerical models that simulate tsunami and tsunami hazard assessment (Hoffmann et al., 2013) which in turn can
23 be used for planning and mitigation and most importantly it can serve as an input for the development of tsunami early
24 warning systems (TEWS).

25 The tsunami hazard of a coast is dependent upon the tsunami sources among many other parameters. The coast of Pakistan
26 lies in close proximity of the Makran subduction zone. The historical tsunami events known in the region are sparse but have
27 been reported by several studies (Dominey-Howes et al., 2006; Heidarzadeh et al., 2008) with the oldest one being in 325
28 BC (Pararas-Carayannis, 2006). The evidence of Paleo-tsunami by MSZ is debatable (Dominey-Howes et al., 2006) as the

29 only instrumentally recorded tsunamigenic earthquake from MSZ was in November 1945, an 8.1 Mw thrust event that
30 occurred almost 8 km southeast of Pasni (Quittmeyer and Jacob, 1979). Another probable source of the tsunami can be
31 landslides such as the one triggered by the 24th September 2013 inland earthquake (Hoffmann et al., 2014; Baptista et al.,
32 2020) or potentially from the landslide on Owen ridge (Rodriguez et al., 2013).

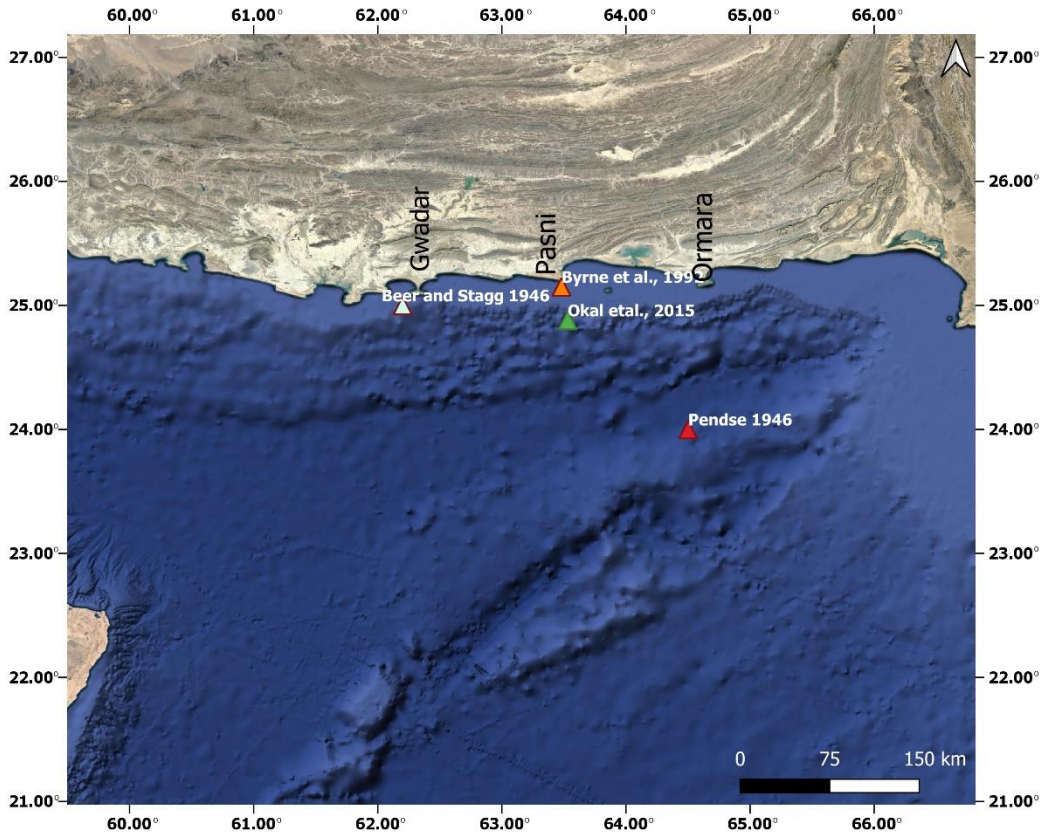
33 The 1945 event being the only recorded event serves as the basis for modelling of the tsunami in the region (Rajendran et al.,
34 2008; Heidarzadeh et al., 2008; Neetu et al., 2011) but the event itself is poorly recorded because of the aftermath of world
35 war II and political situation of then India. We have summarized the historical accounts, eyewitness accounts and newspaper
36 items to come up with the impact of the 1945 tsunami along the coastal cities (then towns) of Pakistan while quantizing the
37 data where ever possible. A field survey is carried out along the three coastal cities of Gwadar, Pasni and Ormara during
38 which inundation parameters along the three cities are identified using the landmarks reported in eyewitness accounts and
39 newspaper items. Similar efforts have been carried out in different areas of the world over many years going back to at least
40 the 1960 Chile tsunami. More recent ones include post tsunami field surveys of 1992 Nicaragua tsunami (Satake et al.,
41 1993), Srilankan field survey of 2004 tsunami (Goff et al., 2006), 2010 Chile tsunami (Tsuji et al., 2010) and 2018 Sulawesi
42 tsunami (Widiyanto et al., 2019; Mikami et al., 2019). All these surveys were carried out immediately after the tsunami event
43 but the study presented here connects a field survey carried out recently with the tsunami event that took place
44 approximately 70 years ago. A similar study that assesses the inundation parameters several years after the event has been
45 conducted in Chile for the 1960 tsunami by Atwater et al., 2013. However, this technique was pioneered by Okal et al.,
46 (2002) and was applied first for the Auletian tsunami.

47 An effort was made by Hoffmann et al. 2013 to review and summarize historical accounts, eyewitness accounts, newspaper
48 items and previously published work for the four countries connected by the Arabian Sea; Oman, Iran, India and Pakistan.
49 According to the study inundation and losses were greatest along what is now the coast of Pakistan. However, the study of
50 Hoffmann et al. 2013 did not report the runups and inundation extents or depths. A study by Okal et al., (2015), also based
51 on field survey and eyewitness accounts quantizes the runup data along a 280 km long segment of Iranian shore. The study
52 reports runup between 2.3–13.7 m and a time delay in the arrival of tsunami, indicating a secondary mechanism such as a
53 landslide. Here, we report runups and inundation extents for the first time, for Gwadar, Pasni and Ormara. The findings are
54 based on the information provided in the eyewitness accounts and newspaper items, a ground survey is conducted to locate
55 the landmarks and come up with the runups and inundation extents along the coast of Gwadar, Pasni and Ormara.

56 **2 Makran Earthquake of 1945 and Tsunami**

57 The 1945 tsunami was a result of a thrusting event of 8.1 Mw at MSZ (Byrne et al., 1992). The earthquake was felt at
58 Muscat, along the entire coast of Makran and many other places of now Pakistan which were far inland, e.g., Montgomery,
59 Dadu, Dera Ismail Khan. It was widely recorded at different stations around the world (Hoffmann et al., 2013). The
60 earthquake was followed by five recorded aftershocks (Byrne et al., 1992). The event generated a tsunami that hit the

61 countries in the north-western Indian Ocean. Fig. 1 shows the relative position of Gwadar, Pasni and Ormara relative to the
62 epicentre location of the 1945 earthquake as reported by different studies.
63



64
65 *Fig. 1 An index map showing the towns of Gwadar, Pasni and Ormara relative to Makran subduction Zone. The triangles show the*
66 *epicenter for the 1945 event after different prior studies (Data plotted on © Google Satellite image).*

67 **3 Impact of the 1945 Makran Tsunami**

68 The aftermath of the 1945 Makran tsunami is not very well recorded due to the political situation of the region. The study
69 reports the impact of the tsunami in general and inundation parameters in specific along three coastal cities Gwadar, Pasni
70 and Ormara. For assessing the inundation parameters, the runup and the inundation extent, a ground survey was conducted to
71 locate the landmarks reported in various newspaper items and eyewitness accounts published in a UNESCO booklet by
72 Kakar et al. 2015. The coordinates of these landmarks were used to extract the inundation parameters using Google Earth.

73 3.1 Gwadar

74 The city of Gwadar is one of the major coastal cities along the coast of Pakistan. The recently built deepwater port has added
75 to the importance of the city. Gwadar is also the hub of Gwadar district today that in itself consists of four sub-districts;
76 Gwadar, Pasni, Ormara and Jiwani.

77 In 1945 Gwadar district consisted of only Peshkan, Sur, Nigor and Pleri along with Gwadar city (see **Fig. 2** (b)). According to
78 the 1931 census report of India (Vol. I, Part I), chapter 1, page 13, Gwadar had been excluded from the census of India
79 because of being in possession of the Sultan of Muscat. Gwadar was in possession of the Sultanate of Oman from 1734 to
80 1958. In 1945, the population of Gwadar town was 5875 according to Records of Oman 1867 – 1947 (see **Fig. 2** (a)). For the
81 same reason, no information on the damages was found in Government reports of Baluchistan nor much was reported in
82 Indian newspapers regarding Gwadar. According to a handwritten letter by the Sultan of Oman (Sa'eed Bin Taimoor),
83 Gwadar suffered estimated financial damages of approximately 70,000 rupees and four lives were lost (**Fig. 2** (c)). The letter
84 has previously been translated as “Five nights ago, an earthquake occurred before dawn time, though no damages happened
85 here as the earthquake was subtle, but the sea rose higher than usual to the point that it entered in the wadi that is behind
86 Masjid Al-Khor mosque at the wadi and news have been received about this earthquake from Al-Hind (India) and Makran,
87 and that Gwadar had been greatly affected and the losses have reached approximately 70,000 Rubbiyya and four have been
88 killed, and it is all in the hands of God.” by (Hoffmann et al., 2013).

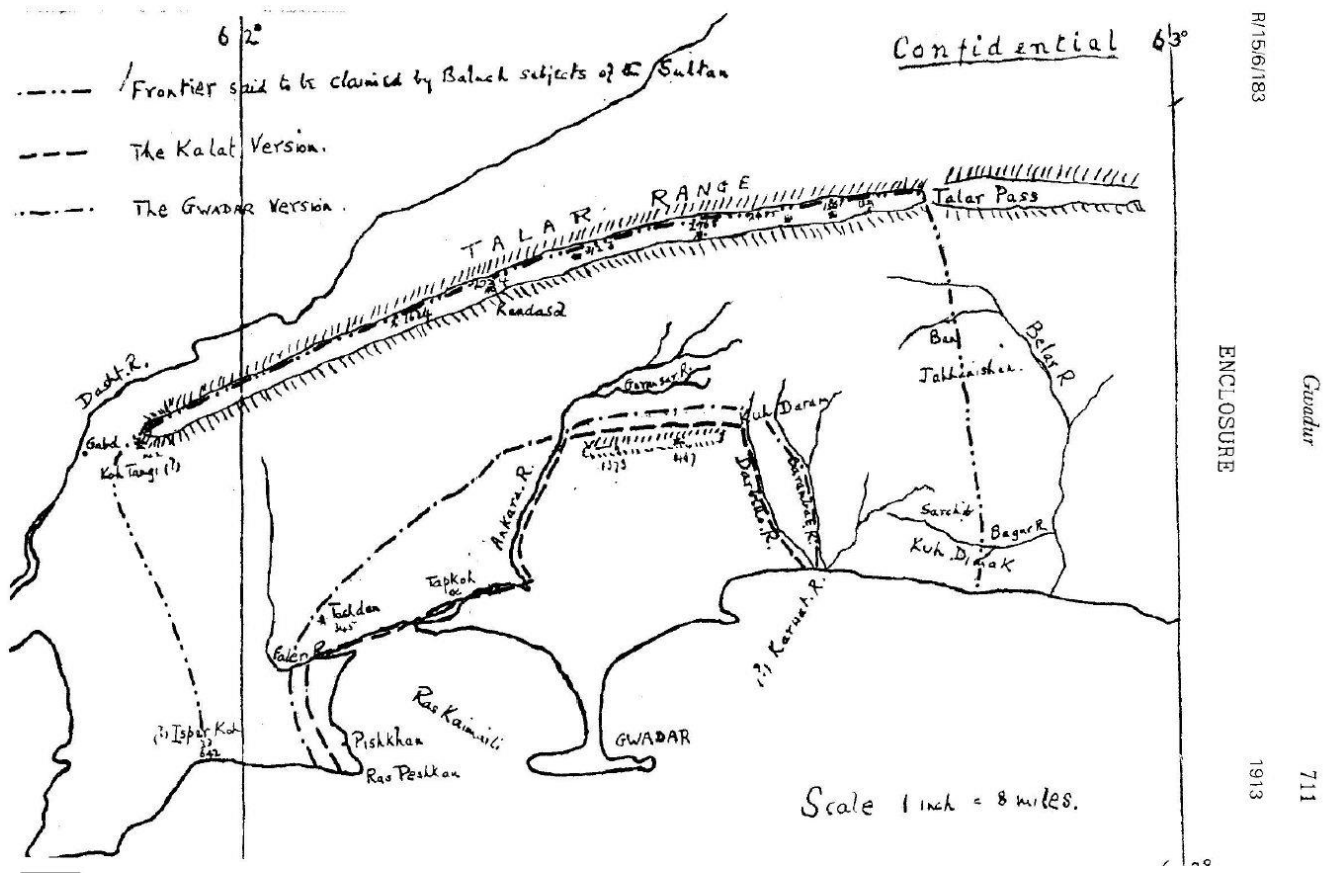
89 The main source of information at Gwadar is eyewitness accounts (**Table 1**) because of the absence of written history. The
90 eyewitnesses along the coast were interviewed at the beginning of this decade and are compiled and published in the form of
91 a UNESCO booklet by Kakar et al. 2015. These eyewitness accounts form the basis of assessing the approximate runup and
92 inundation extents at Gwadar town. From eyewitness accounts, the places and landmarks that were reported as the
93 inundation extent or being inundated are mapped and shown in **Fig. 3**. Mulla Band and Shadu band, the two dams are the
94 highest landmarks that were identified to be inundated by eyewitness accounts. The maximum runup elevation is found at
95 Jamat Khana (11 m). All the points indicate a runup elevation of 5 to 11 m approximately and inundation extent to be in
96 between 200 to 900 m from the eastern bay (**Fig. 3**) whereas none of the eyewitness accounts reports inundation along the
97 western bay other than Master Abdul Rasheed stating, “Water came from the east and crossed to the other side.” The wave
98 was reported to be as high as minaret or to be 3–3.6 m by the eyewitnesses.

99

APPENDIX "A"

POPULATION.

	British Subjects			Muscat Subjects	
	Aghakhani Khojas.	Hindus.	Miscellaneous	Arabs	Baluchis.
<u>Gwadar Town</u>	400	120	305	50	5,000.
<u>Peshkan.</u>	-	-	20	2	500.
<u>Sur.</u>	-	-	30	-	300-
<u>Nigor.</u>	-	-	15	-	1,000.
<u>Pleri.</u>	-	-	1. (Haji Gharib Shah a Baluch Pir or Saint)	-	30.
Total	400	120	371	52	6,830



101

c

There has been an earthquake five nights ago before dawn	لقد حدثت زلزلة منذ خمس ليال قبل الفجر
And by then, damages happened here as if the shaking was light	ولم يحدث ضرر هنا اذ كانت الهزه خفيفه
But the sea rose more than usual	ولكن البحر ارتفع اكثر من المعتاد
Until that it entered the sea of the valley which is behind Al-Jor Mosque	حتى انه دخل في بحري الوادي الذي هو خلف مسجد الجور
And it overwhelmed the creek wharf	وطغى على رصيف الخور
And the news about this earthquake was received from India and Makran	وقد وردت الاخبار عن هذه الزلزله من الهند و مكران
And losses took place in Gwadar estimated at seventy thousand rupees	وقد حدثت في جواذر خاثر تقدر بسبعين الف ربيه
And killed four people	و قتل اربعة اشخاص
And the command belongs to Allah before and after.	والامر لله من قبل و من بعد

لقد حدثت زلزلة منذ خمس ليال قبل الفجر ولم يحدث ضرر هنا اذ كانت الهزه خفيفه
ولكن البحر ارتفع اكثر من المعتاد حتى انه دخل في بحري الوادي الذي هو خلف مسجد الجور
وطغى على رصيف الخور وقد وردت الاخبار عن هذه الزلزله من الهند و مكران
وقد حدثت في جواذر خاثر تقدر بسبعين الف ربيه وقيل اربعة اشخاص
والامر لله من قبل و من بعد

1436
مكة المكرمة

102

103

104

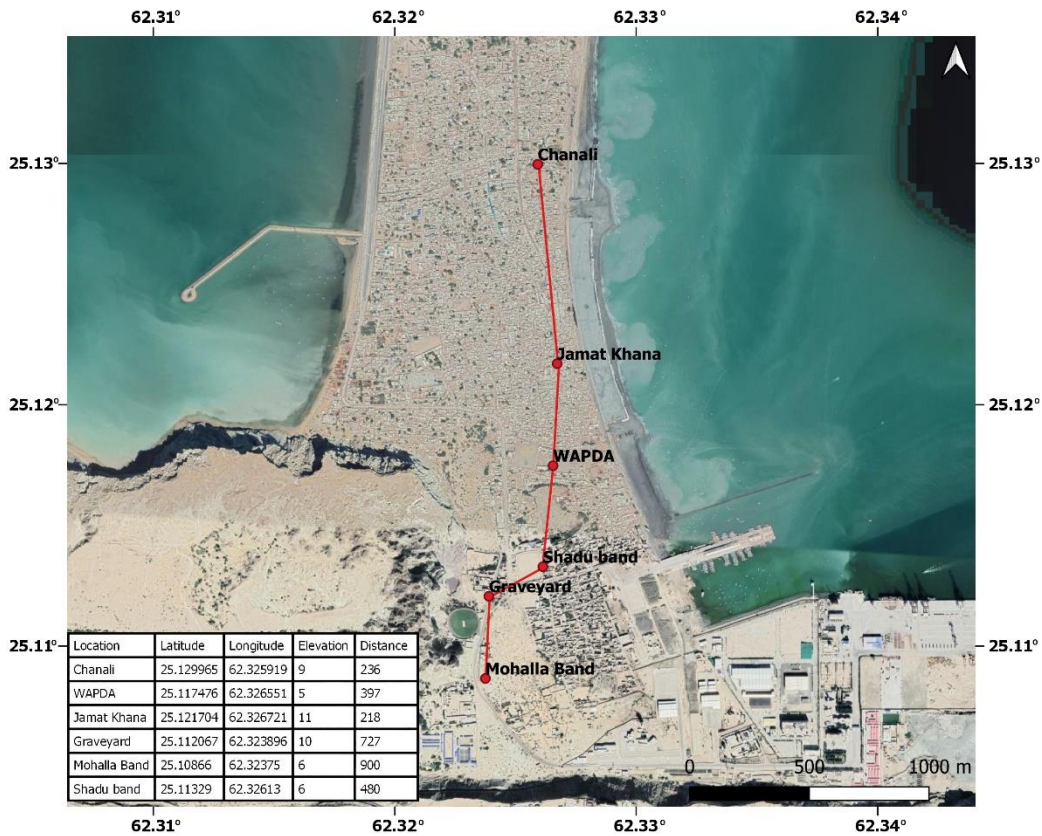
Fig. 2 (a) Population of Gwadar in 1945 from Records of Oman 1867 – 1947. (b) Old map of Gwadar from a letter written by Lieut. Col. J. Rasmay, agent to the Governor General and Chief Commissioner in Balochistan to mark the boundary of Gwadar

105 and Kalat in 1913, printed in Records of Oman 1867-1947. (c) An excerpt of a letter by Sultan of Oman, Sa'eed bin Taimoor along
106 with transliteration of the excerpt.

Table 1 Summary of eyewitness accounts. Here EQ stands for earthquake. Wave heights are not from some datum but are personal interpretation of the interviewee.

Name	Age in 1945 (yrs)	No. of waves	Largest wave	Reported wave heights	Reported arrival times of waves		Inundation extent/depth
Eyewitnesses at Gwadar							
Amina	20	–	–	High as minaret	–	–	Mulla Band, Shadu band, ashkoki, Chanali were completely inundated. Waja Khizer, area in front of Koh e Batil was also inundated.
Mulla Murad Mohammad*	–	–	–	3–3.6 m	–	–	–
Hassan Ali* Souhail	–	–	–	–	–	–	Water Jammal Khana (15 feet deep), WAPDA house was inundated and area where Agha khani community lived was also inundated.
Master Abdul Majeed	7-8	–	–	–	–	–	Water came from east and crossed to the other side. The water also went southward to graveyard near Koh-e-Batil.
Hasan Ali*	–	–	–	–	–	–	Water came from east and went towards Mulla Band. Jammal Khana was used as shelter as the building was strong.
Eyewitnesses at Pasni							
Shamsi Mai	16-17	–	–	6–7.6 m	–	–	2-3 km inland
Master Abdul Rasheed	12	–	2nd	–	Before 6:00 am	Around 6:00 am	Few km inland
Sakhi Dad	10-12	3	3rd	6–7.6 m	6:00 am	–	–
Qadir Buksh* Kushesh	5	–	–	~ 4.5 m	–	–	–
Ajyani Guli	11	3	–	–	–	–	–
Khudi Dost	10-15	–	–	–	30 min after EQ	–	Part of Wadsar drowned.
Karim Buksh	13	7 or 8	–	–	6:00	–	Father's boat was placed by tsunami on the top of mosque.
Haroon*	~1.4	3	–	18, 12, 9 m for 3 waves	–	–	–
Rabuk (Rabia)	5-6	–	–	–	–	–	Water damaged many houses and a mosque.
Ganj Buksh	14-15	–	–	–	–	–	destroyed houses, boats, and debris nearly as far inland as Paraag. Many houses and boats were stranded beside Jaddi Hill
Eyewitnesses at Ormara							

Dildar Sahab	12	3	-	-	-	-	Naik Noor Mohammad Dargah inundated with 4 feet deep water.
Qadir Buksh	15-16	-	-	-	1-1.5 hrs after EQ	-	Water went about as far as the present high school and reached the Naik Noor Mohammad Dragah.
Madni	10-11	-	-	4 m	30 min after EQ	-	-
Shamsudin	6	-	-	-	30 min after EQ	-	-
Master Fateh Mohammad Baloch	15	3	3rd	-	5 a.m	-	Water reached Naik Noor Mohammad Dargah. <i>Gaali</i> , an Indian cargo boats wreckage was carried to Soorani Stream.
Guli	8	-	-	-	-	-	Water reached Naik Noor Mohammad dargah (knee deep). Family took refuge where now is Teshil Municipal Office.
Lari	11	-	1st	-	-	-	Water reached Naik Noor Mohammad Dargah. Water reached the area where present Fisheries Office is.
Sualeh	12-14	-	-	-	30 min after EQ	-	A lot of big fish like sharks and whales were brought on shore near the Customs House. There were dead bodies where the Fisheries Office is now.



111

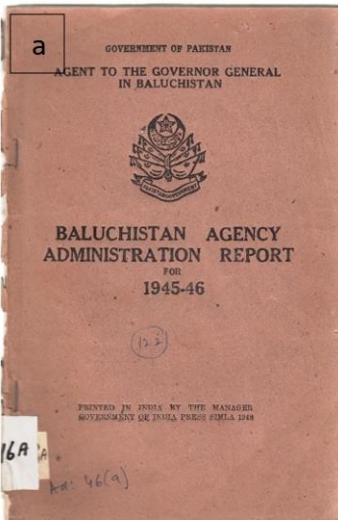
112 **Fig. 3** Locations as identified by eyewitness accounts to have been inundated by the 1945 tsunami, plotted on © Google Satellite
 113 image. The line shows a crude estimate of inundation extents.

114 3.2 Pasni

115 The City of Pasni still remains small even today. It lies on the Makran Coast of the Arabian Sea about 450 km from Karachi.
 116 Administratively, Pasni is the headquarter of the Pasni sub-division of Gwadar district that includes Pasni and
 117 Ormara Tehsils (tehsil - county) as well as Astola Island which lies 40 km ESE of Pasni, in the Arabian Sea. According to
 118 the census of India, Volume IV, Baluchistan (pp. 12) in 1931 total population of Pasni was 1989 (Male: 1090 and Female:
 119 899) which grew to 3616 (Male: 1852 and Female: 1764) in 1941 (Census of India, Volume XIV, Baluchistan, pp. 14).
 120 Therefore, it is estimated that the population of Pasni in 1945 would have been in the 4000s.

121 The Baluchistan Agency Administration Report 1945-46 in many of its sections described the devastation caused by a tidal
 122 wave that was preceded by an earthquake. Part I of Baluchistan Agency Administration Report 1945-46, reports of a severe

123 earthquake on the coast of Makran and Lasbela on 28th November 1945 at 3:30 am. It further reports that Ormara and Pasni
 124 suffered substantial damages. According to the report around 7:00 am, 30 feet high tidal wave struck Pasni, submerging the
 125 entire town while claiming 47 lives (Fig. 4).
 126

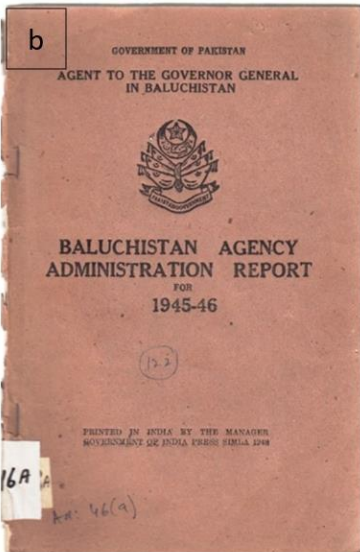


BALUCHISTAN AGENCY ADMINISTRATION REPORT, 1945-46
 PART I
 Lieut.-Col. W. R. Hay, C.S.I., C.I.E., was Agent to the Governor-General during the year under report.
Political and General Summary.
 On the international border there was no serious incident during the year, while internally law and order was satisfactory except for one serious incident on the 6th September 1946 when a lorry was looted on the Fortandemas Quetta road at the boundary between Quetta and Zhob Agencies. One Hindu passenger named Dhanu Ram was murdered in coldblood and robbed of Rs. 1,500. This outrage was committed by Akhio, Sher Ali and Gunhar Khan of the Paganai and Jalaini tribes of Zhob who are relatives of the outlaw Nurullah, the leader of the murderer of Major Barrow. In contrast to this outrage the year was note-worthy for the unusually large crop of outlaws who surrendered in the Zhob Agency due to the energetic policy of the Political Agent. 35 outlaws of varying degrees of importance surrendered during the year.
 Two less important incidents occurred in April and in August in the Loralai Agency. A gang of Khatias murdered Basul Khan Lohrai, M.E.S., gangman working on the Murgha-Musakhel Road, in revenge for the murder of Levy Shafiqul Lal Khan, Khatia, who was murdered the previous year by Basul Khan's family. The second incident occurred when four Marri and Buzdar persons were being escorted to the Musakhel Sub. Jail by a party of three Britishers and a Havildar. A gang of Buzlars attacked the party, shot the Havildar dead, and rescued the prisoners. A local Chigha party of Nohozai Buzlars displaying exemplary resource overtook the gang, shot one of the Buzlars dead and arrested the others. In the same Agency four dangerous outlaws surrendered unconditionally.
 In Mekran smuggling continued to be popular but on several occasions the British Levy Corps were able to apprehend the offenders and the provisions of the Frontier Crimes Regulations were enforced.
 A very severe earthquake occurred on the coast of Mekran and Lasbela on the 28th November, 1945. The shocks began at 3:30 A.M. At Ormara considerable damage was caused to buildings and 71 lives were lost. At Pasni a tidal wave 30 feet high arose at 7:0 A.M. and submerged the whole town. 47 lives were lost. Both at Pasni and at Ormara a large proportion of fishing craft and tackle was destroyed. Salvage and relief work were under-

A very severe earthquake occurred on the coast of Mekran and Lasbela State on the 28th November, 1945. The shock began at 3-30 A.M. At Ormara considerable damage was caused to buildings and 71 lives were lost. At Pasni a tidal wave 30 feet high arose at 7-0 A.M. and submerged the whole town. 47 lives were lost. Both at Pasni and Ormara a large proportion of fishing craft and tackle was destroyed.

A very severe earthquake occurred on the coast of Mekran and Lasbela on the 28th November, 1945. The shocks began at 3-30 A.M. At Ormara considerable damage was caused to buildings and 71 lives were lost. At Pasni a tidal wave 30 feet high arose at 7-0 A.M. and submerged the whole town. 47 lives were lost. Both at Pasni and at Ormara a large proportion of fishing craft and tackle was destroyed. Salvage and relief work were under-

127

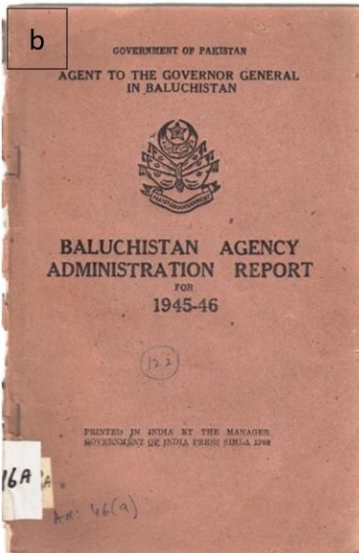


5. *The Pasni Earthquake.*—On the night of 28/29th November 1945 a serious earthquake occurred in the Sea off the South-Western coast of Mekran

which was closely followed up by High tide of water that completely destroyed and washed off the once prosperous and industrious town of Pasni. The village of Kalimat was also seriously damaged. The total casualties to human-beings were 46 dead and several injured, while the loss of property amounted to Rs. 13,33,000.
 An appeal for funds to afford relief to the sufferers was made to all his subjects, by His Highness the Khan, as a result of which a sum of Rs. 40,000 was collected in the State, which together with the generous donation of Rs. 60,000 from the Baluchistan Administration, was distributed among those of the victims of the tragedy who were found to be really in need of help.

128

129

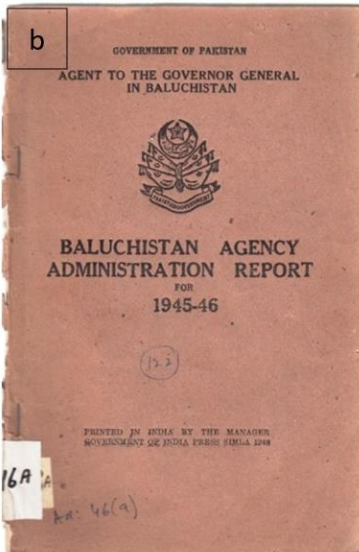


5. *The Pasni Earthquake.*—On the night of 28/29th November 1945 a serious earthquake occurred in the Sea off the South-Western coast of Mekran

which was closely followed up by High tide of water that completely destroyed and washed off the once prosperous and industrious town of Pasni. The village of Kalimat was also seriously damaged. The total casualties to human-beings were 46 dead and several injured, while the loss of property amounted to Rs. 13,33,000.

An appeal for funds to afford relief to the sufferers was made to all his subjects, by His Highness the Khan, as a result of which a sum of Rs. 40,000 was collected in the State, which together with the generous donation of Rs. 60,000 from the Baluchistan Administration, was distributed among those of the victims of the tragedy who were found to be really in need of help.

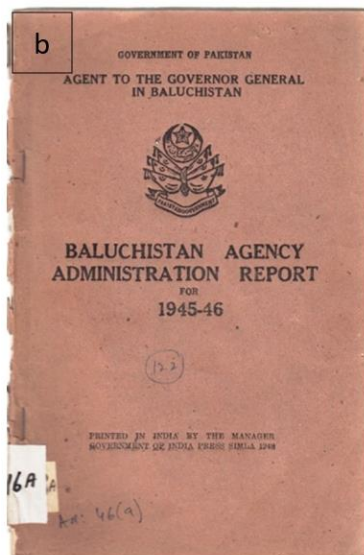
130



5. *The Pasni Earthquake.*—On the night of 28/29th November 1945 a serious earthquake occurred in the Sea off the South-Western coast of Mekran

which was closely followed up by High tide of water that completely destroyed and washed off the once prosperous and industrious town of Pasni. The village of Kalimat was also seriously damaged. The total casualties to human-beings were 46 dead and several injured, while the loss of property amounted to Rs. 13,33,000.

An appeal for funds to afford relief to the sufferers was made to all his subjects, by His Highness the Khan, as a result of which a sum of Rs. 40,000 was collected in the State, which together with the generous donation of Rs. 60,000 from the Baluchistan Administration, was distributed among those of the victims of the tragedy who were found to be really in need of help.



5. *The Pasni Earthquake.*—On the night of 28/29th November 1945 a serious earthquake occurred in the Sea off the South-Western coast of Mekran

which was closely followed up by High tide of water that completely destroyed and washed off the once prosperous and industrious town of Pasni. The village of Kalmat was also seriously damaged. The total casualties to human-beings were 46 dead and several injured, while the loss of property amounted to Rs. 13,33,000.

An appeal for funds to afford relief to the sufferers was made to all his subjects, by His Highness the Khan, as a result of which a sum of Rs. 40,000 was collected in the State, which together with the generous donation of Rs. 60,000 from the Baluchistan Administration, was distributed among those of the victims of the tragedy who were found to be really in need of help.

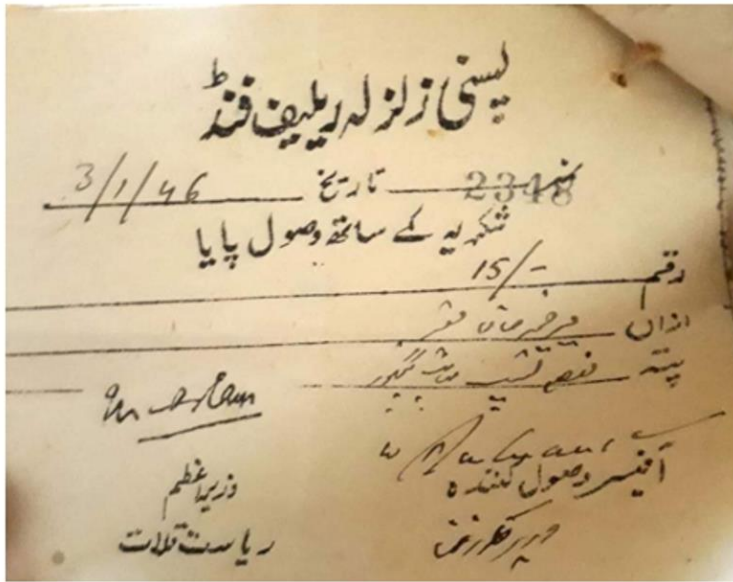
131

132 **Fig. 4 (a) Excerpts of Baluchistan Agency Administration Report, 1945 – 1946, Part I. (b) Excerpts of Baluchistan Agency**
133 **Administration Report, 1945 – 1946, Appendix XI, pp. 59 and 60.**

134

135 Appendix XI Kalat State, of the same, reports, “A serious earthquake occurred in the Sea off the South-Western coast of
136 Makran which was closely followed up by a High Tide of water that completely destroyed and washed off the once
137 prosperous and industrious town of Pasni.” The financial damages and relief efforts at Pasni are also mentioned. It further
138 states that the Khan of Kalat made an appeal for funds to provide relief to the sufferers which resulted in a substantial
139 amount that was afterwards distributed among the people at Pasni (**Fig. 5**).

140 This unfortunate event was widely reported by many newspapers around the world but it was most extensively covered by
141 “Times of India.” Times of India on Friday, 30th November 1945 reported seawater rushed into the town of Pasni and
142 washed away a good number of people. Government buildings including Post and Telegraph office and rest house were
143 washed away. Times of India on Saturday, 1st December 1945 reported, “the town of Pasni is a vast sheet of water with only
144 housetops being visible....Custom House is reported to have been damaged”. Times of India on 6th December 1945 reported
145 that Mr. J. L. Jerath, Director Posts and Telegraphs, Sind and Baluchistan, who had been on H.I.M.S. Hindustan, a naval ship
146 sent to Pasni and Ormara for relief work, upon his return from Pasni and Ormara said that 80% of the huts at Pasni and 60%
147 of the huts at Ormara are estimated to be washed away by the tidal wave (**Fig. 5**). Sind Observer on 6th December 1945
148 reported for Pasni, “The whole village has been totally razed to the ground.....Customs goods and other properties including
149 furniture were carried away by the tidal wave to the other extreme of the village. About 7,000 people here are homeless.”



Mr. Jerath, who left Karachi on Saturday by H.M.I.S. HINDUSTAN, said that at Ormara, most of the huts had been washed away by the tidal wave. At Pasni the destruction was even more widespread. It is estimated that about 60 per cent of the huts have been washed away at Ormara and 80 per cent at Pasni. About 100 persons have probably been killed at either place. There were a number of injured and doctors on board the H. M. I. S. KARACHI, which was sent on Thursday, and H. M. I. S. HINDUSTAN, which left Karachi on Saturday, treated them. Five serious cases, needing hospital treatment, have been brought to Karachi by the HINDUSTAN.

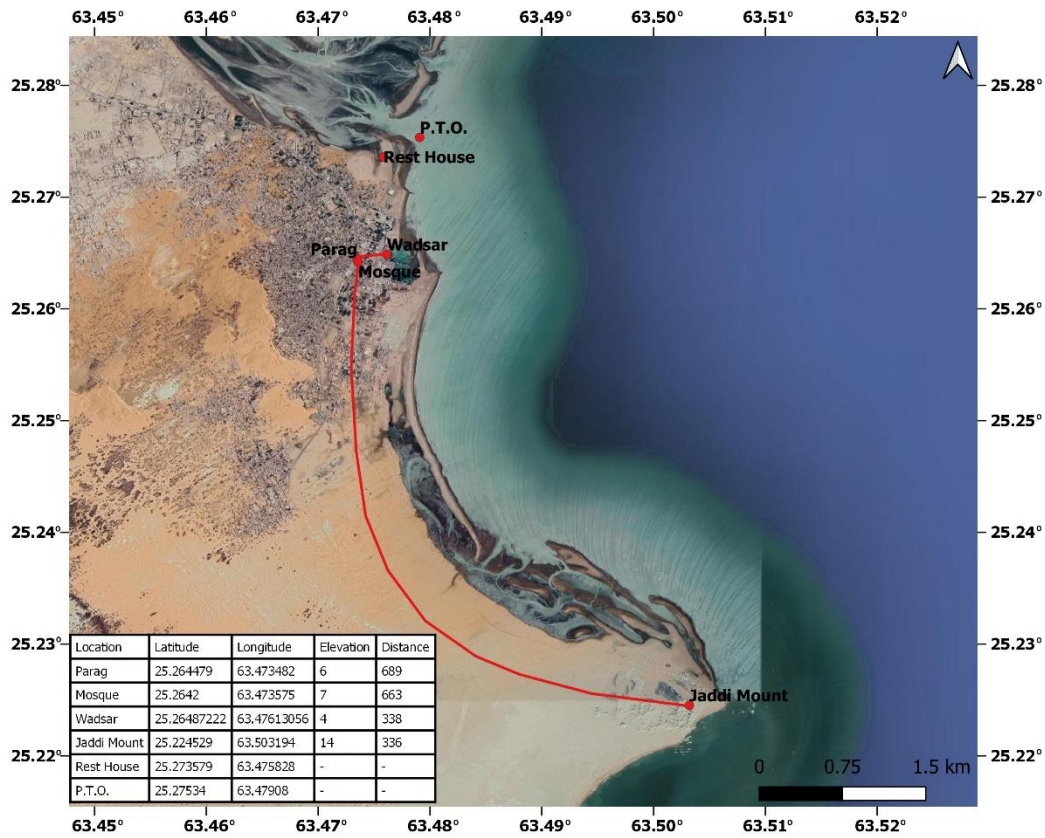
150

151 Fig. 5 Relief efforts at Pasni and Ormara. Slip for an amount of 15 PKR of Pasni Relief Fund received by a survivor of 1945
 152 tsunami (on the right). Times of India clipping showing that Director Post and Telegraph went on the H.M.I.S. Hindustan to Pasni
 153 and Ormara (on the left).

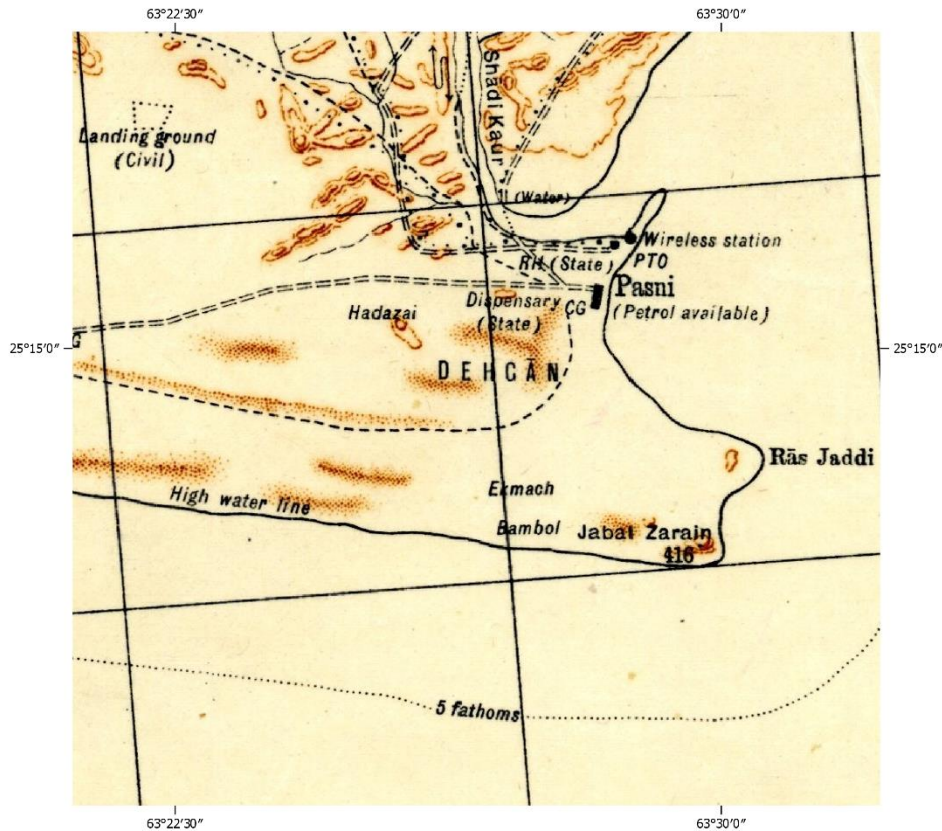
154

155 The inundation extents and runups were not reported in any of the government reports and newspaper items. The places,
 156 Rest House and Post and Telegraph office reported by Times of India as being washed off by the tsunami; were located
 157 through an old map of the Pasni city, from 1943 (a quarter-inch sheet of by the Survey of India. G41-P Turbat, interim
 158 edition 1941, reprinted April 1943, scale 1:253,440), (Fig. 7). PTO was found to be approximately 460 m and Rest House at
 159 570 m from the shoreline at that time. The shoreline of Pasni has changed since 1945, not only as a result of erosion and
 160 deposition of sediments but also because of the event itself as it is reported by many eyewitnesses that part of Pasni slid
 161 underwater.

162 The extents of inundation based on field survey following the eyewitness accounts and reported landmarks therein are
 163 approximately 300 to 700 m from the shoreline whereas the runup elevations are between 4 – 14 m (Fig. 6). Among these
 164 points, Wadsar is the one closest to shore and also has minimum runup elevations but as this area was reported by several
 165 eyewitnesses to have been drowned or slid underwater because of the event therefore we expect that location of Wadsar is
 166 not the actual inundation extent but it is rather an area which was inundated (see Fig. 6). Moreover, the number of waves as
 167 per the eyewitness accounts were three.



170 **Fig. 6** Locations as identified by eyewitness accounts to have been inundated by the 1945 tsunami, plotted on © Google Satellite
 171 image. The line shows a crude estimate of inundation extents. The points which have not been joined through the line were
 172 identified from newspaper accounts.



173

174 Fig. 7 Old map of Pasni. An excerpt from a quarter-inch sheet by the Survey of India. G41-P Turbat, interim edition 1941,
 175 reprinted April 1943, scale 1:253,440.

176

177 3.3 Ormara

178 Ormara still is not very populous but it is an important city of Gwadar district along the Makran coast. Ormara in 1945 came
 179 under the Las Bela state and was part of British Balochistan. The first year for which the population for the city of Ormara
 180 could be found during the study is 1981. According to a report of Pakistan bureau of statistics in 1981 total population of
 181 Ormara was 8265. Therefore, it can be speculated that the city of Ormara had a population of only 1,000s in 1945.

182 In the Baluchistan Agency Administrative Report Appendix XII, the damages by the 1945 event are reported stating that it
 183 resulted in 78 deaths and 165 people were injured though it is unclear whether the tsunami caused the fatalities or the
 184 earthquake itself caused the deaths (Fig. 8).

185 Devastation at Ormara was not much less than the devastation at Pasni. As reported in Times of India, 6th December, Mr.
186 Jerath, Director Posts and Telegraph estimated 60% of huts to have been washed away by tsunami at Ormara. Dawn reported
187 on 2nd December 1945 that the town of Pasni was completely flat and the condition at Ormara is no different from Pasni.

APPENDIX XII.
ADMINISTRATION REPORT OF LAS BELA STATE FOR THE YEAR
1945-46.

CHAPTER I.—General and Political.

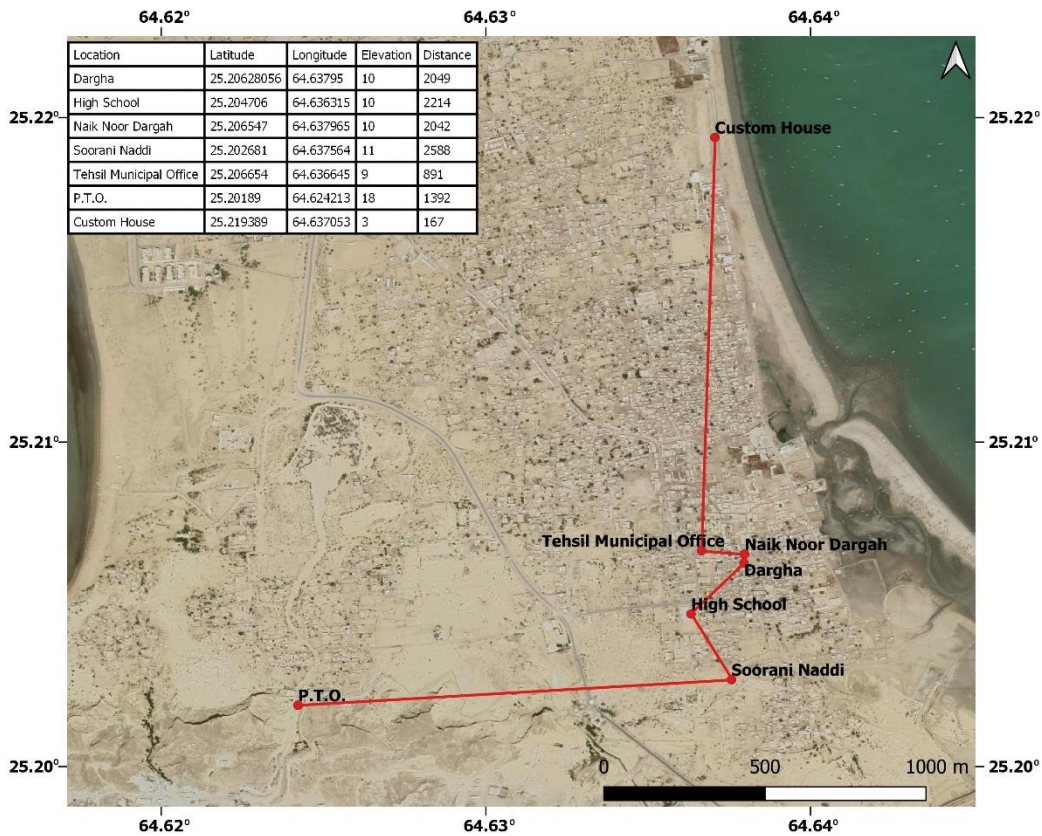
4. A severe earthquake occurred at Ormara on the 27th November 1945 resulting in 78 deaths and injuries to 165 persons. In addition, 12 persons were found missing. The loss of property is estimated to range between three to four lakhs of rupees. Relief measures were taken at the time.

188
189 **Fig. 8 Excerpts of Baluchistan Agency Administration Report, 1945 – 1946, Appendix XII**

190
191 Eyewitnesses remembered the arrival of three waves after the earthquake and destruction of an Indian cargo boat, *Gaali* and
192 the wreckage being carried to Sorani stream. The waves arrived either an hour or an hour and a half after the earthquake. The
193 accounts have been quantified to get inundation extent and runup at Ormara, through a ground survey. It is found that the
194 maximum runup elevation is approximately 11 m and the maximum inundation extent is almost 2.5 km (**Fig. 9**).

195 The Post and Telegraph Office (PTO) was reported by the Times of India to have been inundated during the 1945 event. The
196 PTO was located through an old map of the city (a quarter-inch sheet by the Survey of India. G41-Q Ormara, second edition
197 1937, scale 1:253,440) and was found to be approximately 1 km from the shoreline.

198 Interviews of local fishermen at Ormara in the 1970s, reported in (Page et al., 1979) provided evidence of uplift at Ormara
199 due to the 1945 earthquake which is interpreted by the author to be around 2 m. The same is evident by the interview of
200 Qadir Buksh, “The shoreline shifted. Before the event the shore was inland of where it is today.” (Kakar et al., 2015a).



202

203 **Fig. 9** Locations as identified by eyewitness accounts to have been inundated by the 1945 tsunami, plotted on © Google Satellite
 204 image. The line shows a crude estimate of inundation extents. The point which has not been joined through the line was identified
 205 from newspaper accounts.

206 4. Results and Discussion

207 The historical accounts for large earthquakes along the Makran Subduction zone are sparse and disputable. Nevertheless, the
 208 possibility of large earthquakes cannot be ruled out. With Megacities such as Karachi (Pakistan) and Mumbai (India) and
 209 many other growing coastal cities such as Gwadar (Pakistan), Chabahar (Iran) and Batinah (Oman), the seismic hazard from
 210 Makran Subduction Zone and risk of ensuing tsunamis cannot be overlooked. The growing population and large investments
 211 in infrastructure along the coasts bordering the Arabian Sea demand reliable risk assessment for tsunami in the region but not
 212 enough data is available for the same.

213 In many cases, historical accounts are a valuable source of information for the reconstruction of past tsunami events
 214 (Atwater et al., 2013; Dominey-Howes et al., 2006) where scientific data is not present. We first summarize the description
 215 of the 1945 event in newspaper items, historical reports and eyewitness accounts and then use eyewitness accounts and
 216 newspaper items combined with a field survey to extract the runups and inundation extents for coastal cities of Pakistan
 217 through the reported tsunami observations there-in.

218 At Gwadar, although there was not much damage the maximum runup is found to be 11 m and the maximum inundation
 219 extent is around 900 m. These extents have been derived from the landmarks identified by the eyewitnesses but one of the
 220 eyewitnesses (Master Abdul Majeed) also reported, “Water came from the east and crossed to the other side” which is
 221 indicative of tsunami engulfing the entire landmass along the east to west stretch. None of the other eyewitnesses reported
 222 such inundation, The study does not use this account to conclude that the water might have swept across the entire tombolo
 223 as many other survivors had reported water reaching up to certain landmarks only. Another survivor of the event, Amina
 224 reported that the “huge wave” did not enter the city. She further reported the water reached the mosque; water was
 225 everywhere with no place to go but the water went further than the mosque. She also named some places that were inundated
 226 by the tsunami, such as the Mulla band and Shadu band (Kakar et al., 2015b). The water reaching the Mulla Band, reported
 227 by Amina and Hasan Ali might be that they were reporting “Mohalla Band” rather than “Mulla Band” or “Mohalla Band” is
 228 the new name of the neighbourhood just beside the Gwadar Miniport which was previously called as “Mulla Band”, an area
 229 that is very likely to be inundated during the 1945 event. Shadu Band is another neighbourhood beside the new football
 230 stadium of Gwadar. In order to be sure if the interpretation of the locations was right, interviewers of the Amina were
 231 interviewed as Amina had passed away.

232 The maximum runup and inundation extent at Pasni as measured are approximately 14 m and 700 m, respectively. The
 233 inundation extents are not the actual extents for every point marked on **Fig. 3** but in some cases mark the landmarks that were
 234 identified as inundated. Moreover, the shoreline at Pasni has changed drastically since 1945 and the inundation extents for
 235 most of the points have been extracted using the recent imagery from Google Earth. Therefore, these two factors can
 236 contribute to the fact that the actual inundation extent in 1945 could have been greater than reported here.

237 At Ormara the maximum runup and inundation extents are approximately 11 m and 2.5 km (from Western Bay after the
 238 epicenter from (Byrne et al., 1992) (see **Table 2**). The inundation extent at Ormara is the greatest among all the towns
 239 considered in the study although Pasni was much closer to the epicentre. This might be contributed by the fact that Pasni had
 240 sand dunes near the town which according to many eyewitnesses saved their lives as it was a place of refuge whereas at
 241 Ormara no such natural defence was present beside the town.

242

243 **Table 2 Impact of 1945 Makran tsunami along the coastal cities of Pakistan.**

City	Maximum runup (m)	Maximum Inundation extent (m)	Number of Waves	Maximum Wave Height (m)	Casualties	Financial Damages (Rs.)	Present day equivalent (US \$)
------	-------------------	-------------------------------	-----------------	-------------------------	------------	-------------------------	--------------------------------

Gwadar	56	700	–	3–6	3–4	70,000	~453
Pasni	7.6	1000	3	9.1	47	1,333,000	~8630
Ormara	11	2500*	3	–	76	300,000- 400,000	~1945–2589

*from Western Bay

244

245

246

247

248

249

250

If we take the same population as 1941 (1939) and find the percentage of people who lost their lives to the 1945 tsunami event at Pasni, it is found to be approximately 1.3% (considering the population of 1941 as the nearest estimate of population in 1945). The town of Ormara had an estimated population of nearly 1000 and sustained 76 casualties that give approximately 8% of the population wiped off by the event.

251

5 Conclusions

252

253

254

255

256

257

This paper draws on the eyewitness accounts and newspaper items to estimate the runup and inundation extent at Gwadar, Pasni, Ormara and Karachi. Pasni and Omara were the most severely affected cities. The inundation extent at Ormara is the greatest among all the cities considered in the study although Pasni was much closer to the epicentre. The uncertainty is inherent to the parameters derived here due to reasons such as personal interpretation of the event survivors and survey being conducted after 70 years of the event. Therefore, the inundation parameters presented here may be a crude approximation of the actual parameters but it still paints a picture of the wreck-havoc caused by the 1945 Makran tsunami.

258

259

260

261

The data collected in the form of eyewitness accounts, archival reports and newspaper accounts from countries bordering the Arabian Sea should be used to draw reliable limits on the source of the earthquake and ensuing tsunami. Similar studies in the neighbouring countries can further facilitate the cause and contribute to reliable risk assessment of the coasts along the Arabian Sea.

262

263

264

265

266

267

268

269

The time of arrival of waves at Pasni as reported by multiple survivors was around 6 a.m. whereas only Khudi Dost reports the waves to have arrived almost half an hour after the earthquake (**Table 1**). It is reported in Baluchistan Agency Administration Report (**Fig. 4**), “*At Pasni a tidal wave 30 feet high arose at 7-0 A.M. and submerged the whole town.*” Therefore, it is evident that there is a time difference of 2–3 hours between the earthquake and the arrival of the largest wave. This finding is in concordance with the eyewitness accounts from Iran and the finding is reported in (Okal et al., 2015) and with the observation of (Beer and Stagg, 1946). This time delay in the arrival of tsunami is suggestive of some secondary mechanism such as landslide, associated with the earthquake. This can also be the reason why most of the witnesses reported that the 2nd or the 3rd wave as being the highest of the waves that attacked the coast.

270

271

272

The majority of the eyewitnesses along the Makran coast of Pakistan had reported the time of arrival of the tsunami as half an hour after the earthquake. (Beer and Stagg, 1946) reported, “The first tidal observation was made at 9 hr. 47 min. local time, but it was then noted that the tidal-levels were well above their normal value, suggesting that an earlier wave may

273 indeed have arrived by that time.” Therefore, the time reported here by the eyewitnesses as thirty minutes after the
274 earthquake might be the time of arrival of the first wave associated with the earthquake whereas the larger wave generated
275 by an ancillary phenomenon arrived 2–3 hours after the earthquake.

276 The total number of estimated fatalities associated with the Makran earthquake and ensuing tsunami vary between 300
277 (Ambraseys and Melville, 1982) to 4000 (https://www.ngdc.noaa.gov/hazards/tsu_db.shtml). The more widely reported
278 number of fatalities is 4000 (e.g., Heck, 1947; Heidarzadeh et al., 2008; Rajendran et al., 2008) but this figure is associated
279 with only the region of Karachi and Indus Delta rather than the Makran coast of Pakistan. According to Times of India, 5th
280 December 1945, the reports of 4000 casualties came from a party of nine congressmen. It was reported only for the 100
281 miles coast from Karachi to Keti-bunder (a region in Indus Delta). These reports, according to an express letter written by
282 the Chief Secretary to the Government of Sind, to the Secretary to the Government of India were “greatly exaggerated.”

283 Moreover, according to the comment of the Chief Secretary to the Government of Sind on estimates of the loss of lives by
284 congressmen, published in Times of India, 6th December 1945, “They were highly exaggerated. The coastline is sparsely
285 populated. The sub-divisional officials have asked for only small grants for relief, indicating that the damage caused is not as
286 heavy as reported.”

287

288

289 **Author Contribution**

290 Hira Ashfaq Lodhi prepared the manuscript, identified the landmarks from eyewitness accounts and newspaper items for the
291 field survey. Shoaib Ahmed conducted the field survey. Haider Hasan searched for archival documents.

292 **Competing Interests**

293 The authors declare that they have no conflict of interest.

294 **Funding**

295 The field survey was funded under UNDP project “Tsunami and Earthquake Preparedness in Coastal Areas of Pakistan.”

296 **Acknowledgments**

297 We acknowledge the support extended by Dr. Brian F. Atwater. His critical reviews have improved the manuscript. We also
298 acknowledge the support extended by Dr. Gösta Hoffman for sharing the excerpt of the Sultan's letter. We also acknowledge
299 our reviewers for their input.

300 **References**

- 301 Ambraseys, N. N. and Melville, C. P.: A history of Persian Earthquakes, Cambridge University Press, Cambridge, U.K., 219
302 pp., 1982.
- 303 Atwater, B. F., Cisternas, M., Yulianto, E., Prendergast, A. L., Jankaew, K., Eipert, A. A., Fernando, W. I. S., Tejakusuma,
304 I., Schiappacasse, I., and Sawai, Y.: The 1960 tsunami on beach-ridge plains near Maullín, Chile: Landward descent,
305 renewed breaches, aggraded fans, multiple predecessors, 26, 2013.
- 306 Baptista, M. A., Miranda, J. M., Omira, R., and El-Hussain, I.: Study of the 24 September 2013 Oman Sea tsunami using
307 linear shallow water inversion, Arab J Geosci, 13, 606, <https://doi.org/10.1007/s12517-020-05632-z>, 2020.
- 308 Beer, A. and Stagg, J. M.: Seismic Sea-Wave of November 27, 1945, 4002, 63, 1946.
- 309 Byrne, D. E., Sykes, L. R., and Davis, D. M.: Great Thrust Earthquakes and Aseismic Slip Along the Plate Boundary of
310 Makran Subduction Zone, 97, 449–478, 1992.
- 311 Dominey-Howes, D. T., Humphreys, G. S., and Hesse, P. P.: Tsunami and palaeotsunami depositional signatures and their
312 potential value in understanding the late-Holocene tsunami record, 16, 1095–1107, 2006.
- 313 Goff, J., Liu, P. L.-F., Higman, B., Morton, R., Jaffe, B. E., Fernando, H., Lynett, P., Fritz, H., Synolakis, C., and Fernando,
314 S.: Sri Lanka Field Survey after the December 2004 Indian Ocean Tsunami, Earthquake Spectra, 22, 155–172,
315 <https://doi.org/10.1193/1.2205897>, 2006.
- 316 Heck, N. H.: List of seismic sea waves, 37, 269–286, 1947.
- 317 Heidarzadeh, M., Pirooz, M. D., Zaker, N. H., Yalciner, A. C., Mokhtari, M., and Esmaeily, A.: Historical tsunami in the
318 Makran Subduction Zone off the southern coasts of Iran and Pakistan and results of numerical modeling, Ocean Engineering,
319 35, 774–786, <https://doi.org/10.1016/j.oceaneng.2008.01.017>, 2008.
- 320 Hoffmann, G., Rupprechter, M., Balushi, N. A., Grützner, C., and Reicherter, K.: The impact of the 1945 Makran tsunami
321 along the coastlines of the Arabian Sea (Northern Indian Ocean) – a review, Zeit fur Geo Supp, 57, 257–277,
322 <https://doi.org/10.1127/0372-8854/2013/S-00134>, 2013.
- 323 Hoffmann, G., Al-Yahyai, S., Naeem, G., Kociok, M., and Grützner, C.: An Indian Ocean tsunami triggered remotely by an
324 onshore earthquake in Balochistan, Pakistan, 42, 883–886, <https://doi.org/10.1130/G35756.1>, 2014.
- 325 Kakar, D. M., Naeem, G., Usman, A., Mengal, A., Beni, A. N., Afarin, M., Ghaffari, H., Fritz, H. M., Pahlevan, F., Okal, E.,
326 Hamzeh, M. A., Ghasemzadeh, J., Al-Ballushi, N. S., Hoffmann, G., Roepert, A., Srinivasalu, S., and Andrade, V.:
327 Remembering the 1945 Makran Tsunami: Interviews with the Survivors Beside the Arabian Sea, UNESCO/IOC, 2015a.

- 328 Kakar, D. M., Naeem, G., Usman, A., Mengal, A., Baksh, D., Nisar, M., Baloch, A., Warr, M. B., Beni, A. N., Afarin, M.,
329 Ghaffari, H., Fritz, H. M., Pahlevan, F., Okal, E., Hamzeh, M. A., Ghasemzadeh, J., Balushi, N. A., Hoffmann, G., Roepert,
330 A., Srinivasalu, S., Andrade, V., Alharti, A. R., and Bhatt, N.: Remembering the 1945 Makran Tsunami: Interviews with the
331 Survivors Beside the Arabian Sea (in Urdu), UNESCO IOC, 2015b.
- 332 Mikami, T., Shibayama, T., Esteban, M., Takabatake, T., Nakamura, R., Nishida, Y., Achiari, H., Rusli, Marzuki, A. G.,
333 Marzuki, M. F. H., Stolle, J., Krautwald, C., Robertson, I., Aránguiz, R., and Ohira, K.: Field Survey of the 2018 Sulawesi
334 Tsunami: Inundation and Run-up Heights and Damage to Coastal Communities, *Pure Appl. Geophys.*, 176, 3291–3304,
335 <https://doi.org/10.1007/s00024-019-02258-5>, 2019.
- 336 Neetu, S., Suresh, I., Shankar, R., Nagarajan, B., Sharma, R., Shenoi, S. S. C., Unnikrishnan, A. S., and Sundar, D.: Trapped
337 waves of the 27 November 1945 Makran tsunami: observations and numerical modeling, 59, 1609–1618,
338 <https://doi.org/10.1007/s11069-011-9854-0>, 2011.
- 339 Okal, E. A., Synolakis, C. E., Fryer, G. J., Heinrich, P., Borrero, J. C., Ruscher, C., Arcas, D., Guille, G., and Rousseau, D.:
340 A Field Survey of the 1946 Aleutian Tsunami in the Far Field, *Seismological Research Letters*, 73, 490–503,
341 <https://doi.org/10.1785/gssrl.73.4.490>, 2002.
- 342 Okal, E. A., Fritz, H. M., Hamzeh, M. A., and Ghasemzadeh, J.: Field Survey of the 1945 Makran and 2004 Indian Ocean
343 Tsunamis in Baluchistan, Iran, *Pure Appl. Geophys.*, 172, 3343–3356, <https://doi.org/10.1007/s00024-015-1157-z>, 2015.
- 344 Page, W. D., Alt, J. N., Cluff, L. S., and Plafker, G.: Evidence for the recurrence of large-magnitude earthquakes along the
345 Makran coast of Iran and Pakistan, 52, 533–547, 1979.
- 346 Pararas-Carayannis, G.: THE POTENTIAL OF TSUNAMI GENERATION ALONG THE MAKRAN SUBDUCTION
347 ZONE IN THE NORTHERN ARABIAN SEA. CASE STUDY: THE EARTHQUAKE AND TSUNAMI OF NOVEMBER
348 28, 1945, 24, 27, 2006.
- 349 Quittmeyer, R. C. and Jacob, K. H.: Historical and Modern Seismicity of Pakistan, Afghanistan, Northwestern India and
350 Southeastern Iran, 69, 773–823, 1979.
- 351 Rajendran, C. P., Ramanamurthy, M. V., Reddy, N. T., and Rajendran, K.: Hazard implications of the late arrival of the 1945
352 Makran tsunami, 95, 5, 2008.
- 353 Rodriguez, M., Chamot-Rooke, N., Hébert, H., Fournier, M., and Huchon, P.: Owen Ridge deep-water submarine landslides:
354 implications for tsunami hazard along the Oman coast, *Nat. Hazards Earth Syst. Sci.*, 13, 417–424,
355 <https://doi.org/10.5194/nhess-13-417-2013>, 2013.
- 356 Satake, K., Bourgeois, J., Abe, K., Abe, K., Tsuji, Y., Imamura, F., Lio, Y., Katao, H., Noguera, E., and Estrada, F.: Tsunami
357 field survey of the 1992 Nicaragua earthquake, *Eos Trans. AGU*, 74, 145–157, <https://doi.org/10.1029/93EO00271>, 1993.
- 358 Tsuji Y., Ohtoshi K., Nakano S., Nishimura Y., Fujima K., Imamura F., Kakinuma T., Nakamura Y., Imai K., Goto K.,
359 Namegaya Y., Suzuki S., Shiroshita H., and Matsuzaki Y.: Field Investigation on the 2010 Chilean Earthquake Tsunami
360 along the Comprehensive Coastal Region in Japan, *Journal of Japan Society of Civil Engineers, Ser. B2 (Coastal
361 Engineering)*, 66, 1346–1350, <https://doi.org/10.2208/kaigan.66.1346>, 2010.
- 362 Widiyanto, W., Santoso, P. B., Hsiao, S.-C., and Imananta, R. T.: Post-event Field Survey of 28 September 2018 Sulawesi
363 Earthquake and Tsunami, *Sea, Ocean and Coastal Hazards*, <https://doi.org/10.5194/nhess-2019-91>, 2019.

364