中央地質調查所
CENTRAL GEOLOGICAL SURVEY

A preliminary study on the tsunami deposits appeared in the archeological test pits, Heping Island, Keelung

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Introduction

- In recent year, there are lots of tsunami risks which occurred in coastal towns, so that we must pay attention to it.
- In Taiwan, there are lots of researches which focus on issues of the **tsunami warning**, **geophysical modeling** and **historic record**, except **tsunami deposits**.

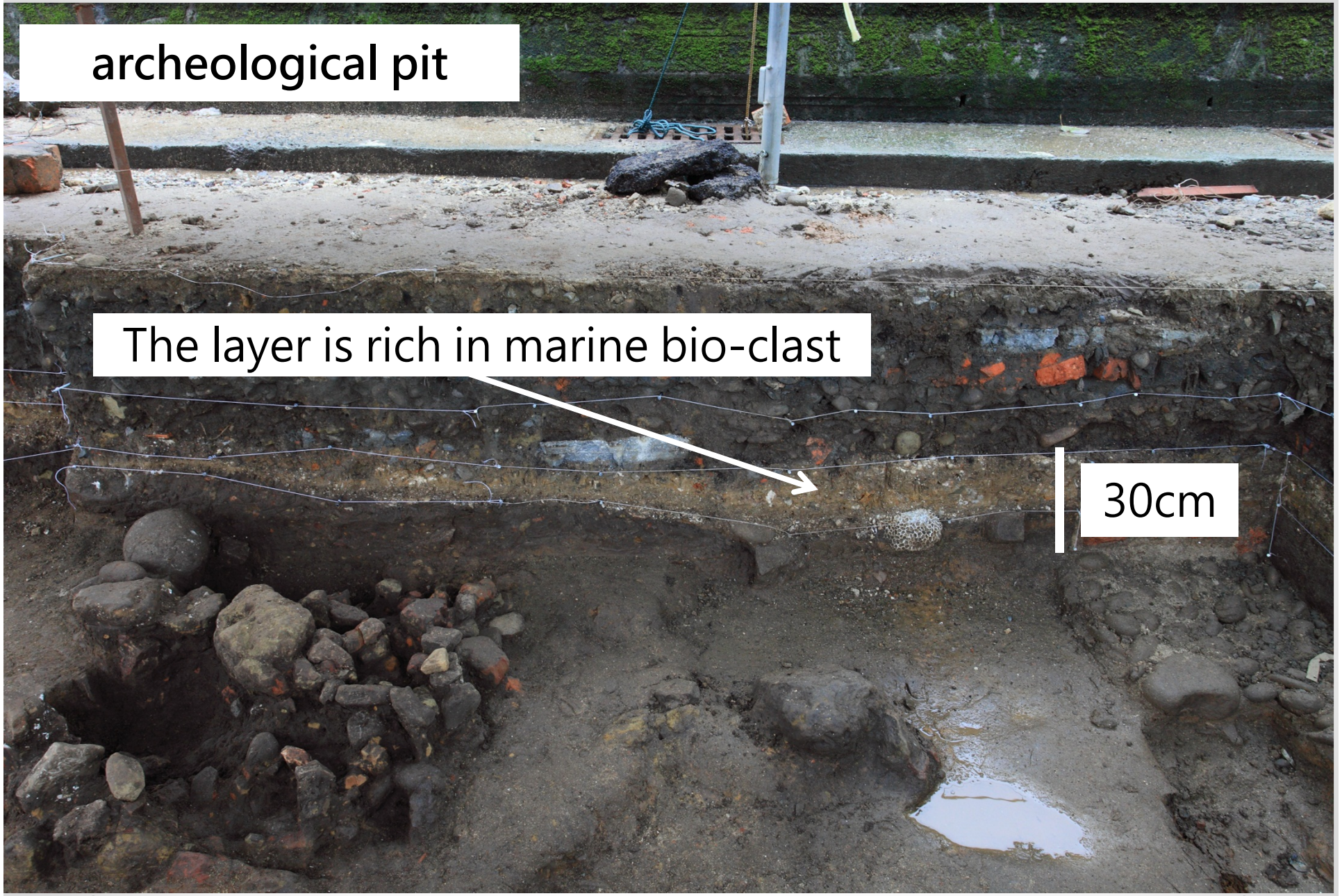
Keelung Tsunami Event: 1867/12/18

「淡水廳志」記載：

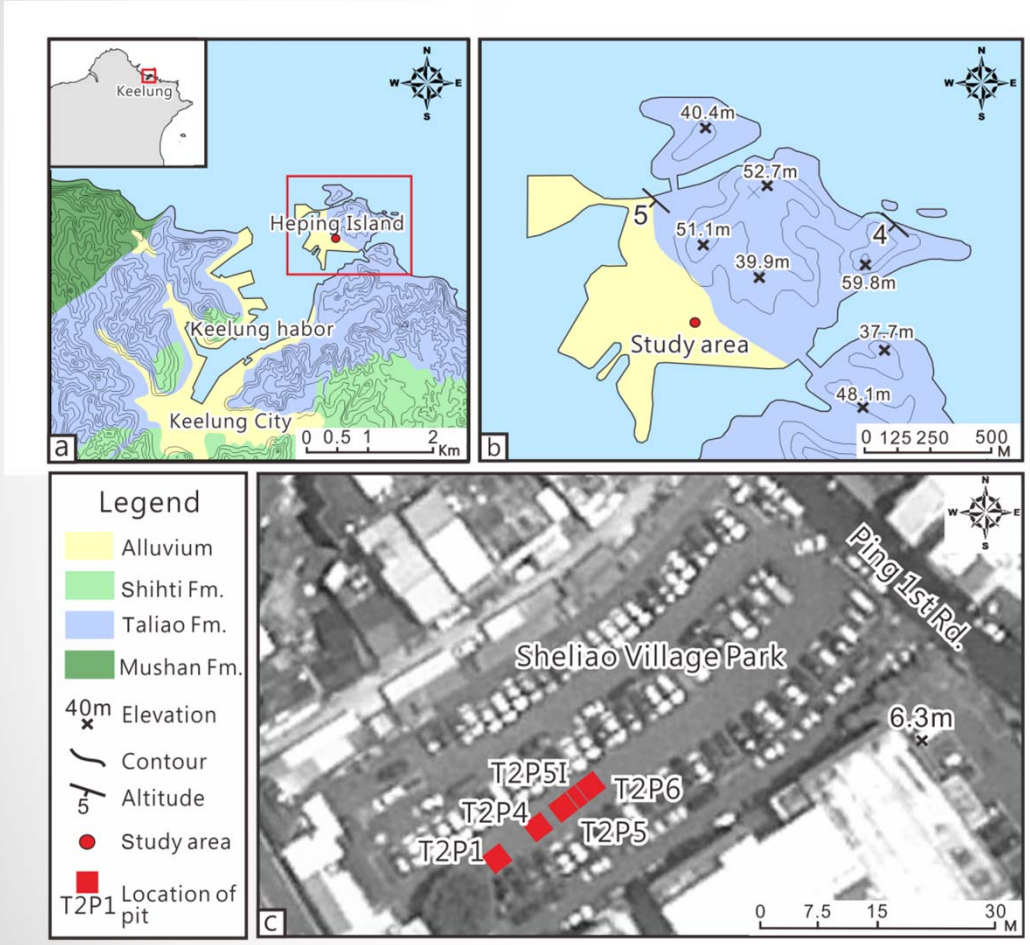
「同治六年發生大地震，雞籠頭、金包里沿海，山傾地裂，海水暴漲，屋宇傾壞，漲數百人。」

《福爾摩沙紀事：馬偕台灣回憶錄》記載：

「數年之前，在雞籠聽到隆隆之聲，港內的水忽然退去.....海水像軍隊衝鋒似地回來，越過堤防，把沿岸低地上的房屋都掃去。」

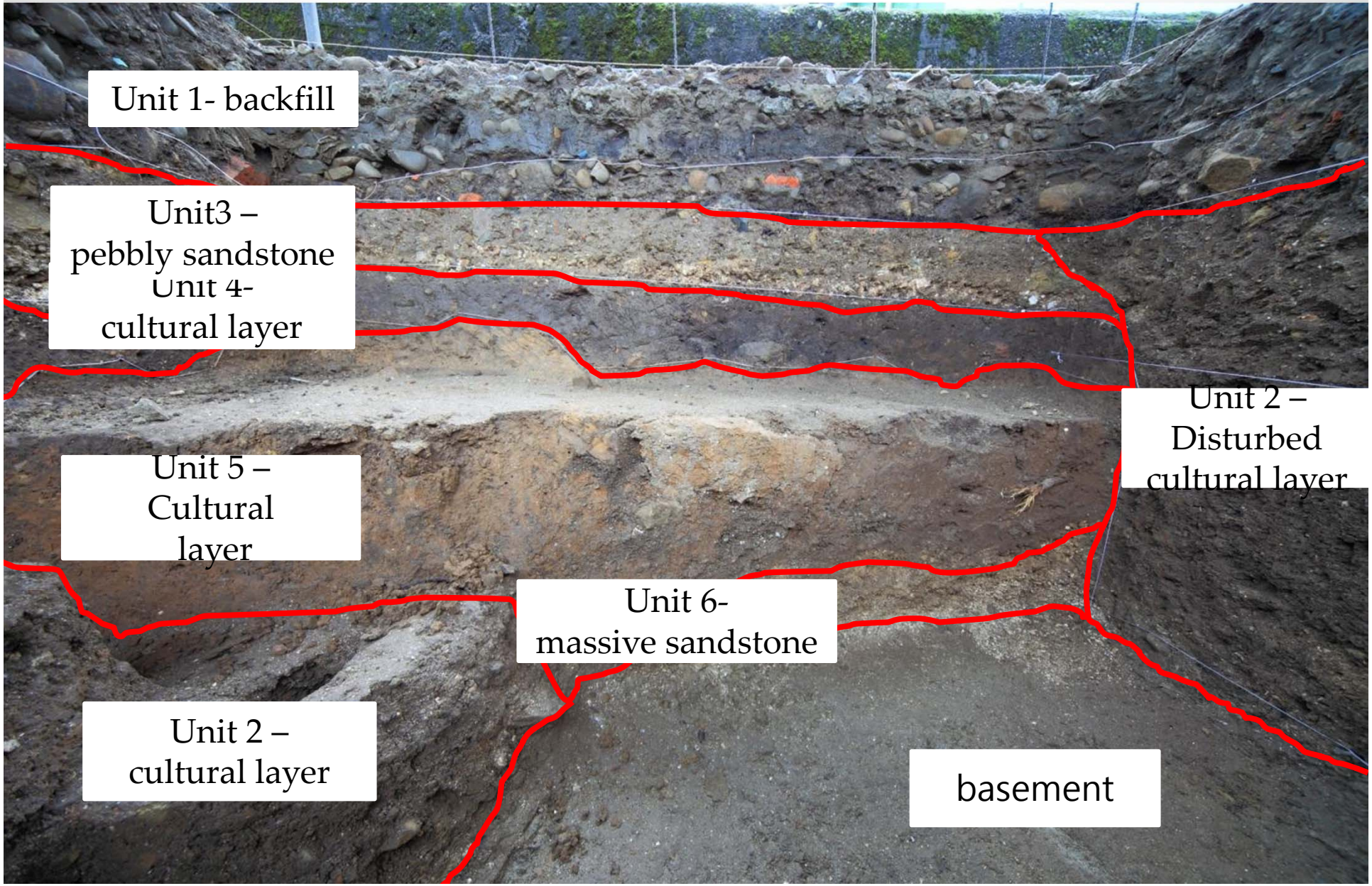

archeological pit
The layer is rich in marine bio-clast
30cm

Study area

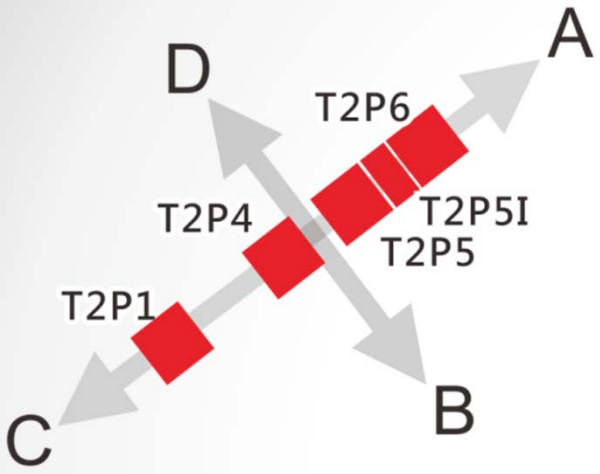


- Pits are located on Holocene Alluvium, **southwest of Heping Island**.
- Elevation of pits are **6.3m**.

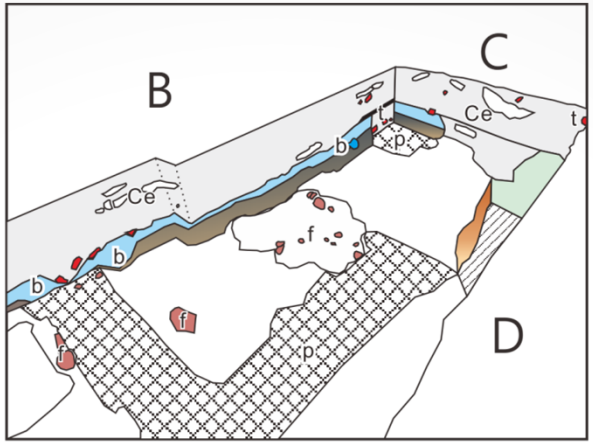
Layer and Succession

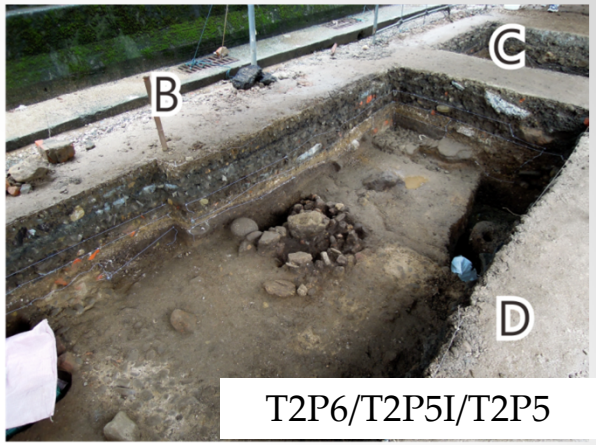


Profile

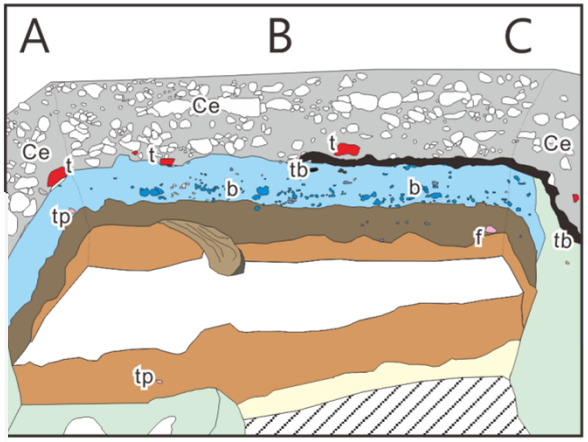


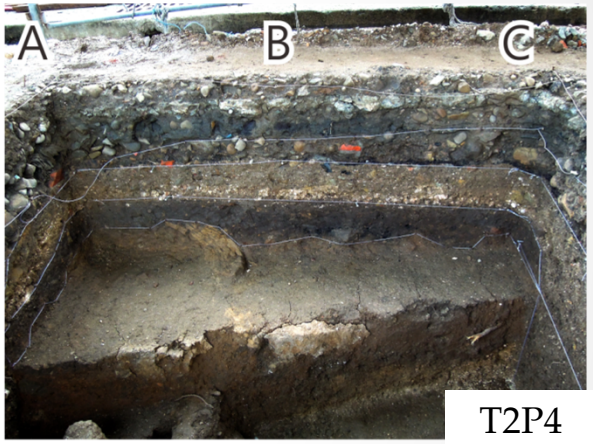
Unit 1	Japanese tile (tb)
Unit 2	Pink tile(tp)
Unit 3	Pavement(p)
Unit 4	Firestone(f)
Unit 5	Tile (t)
Unit 6	Cement (Ce)
Basement	Bio-clast(b)



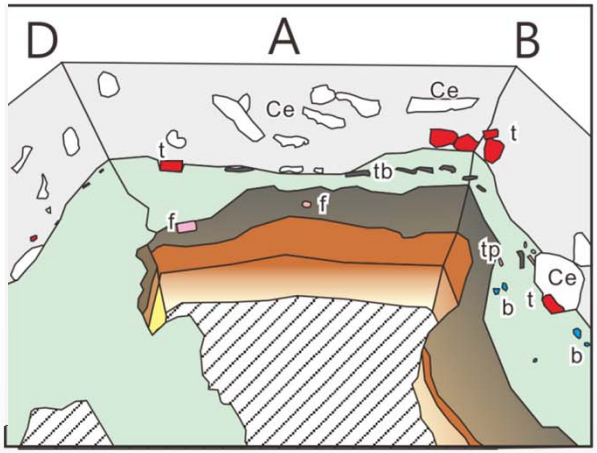


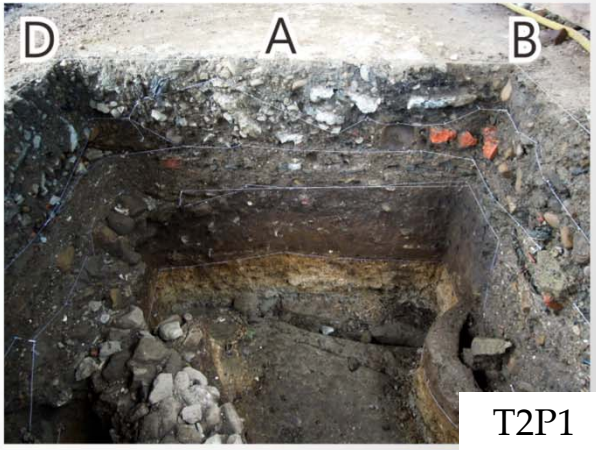
T2P6/T2P5I/T2P5





T2P4

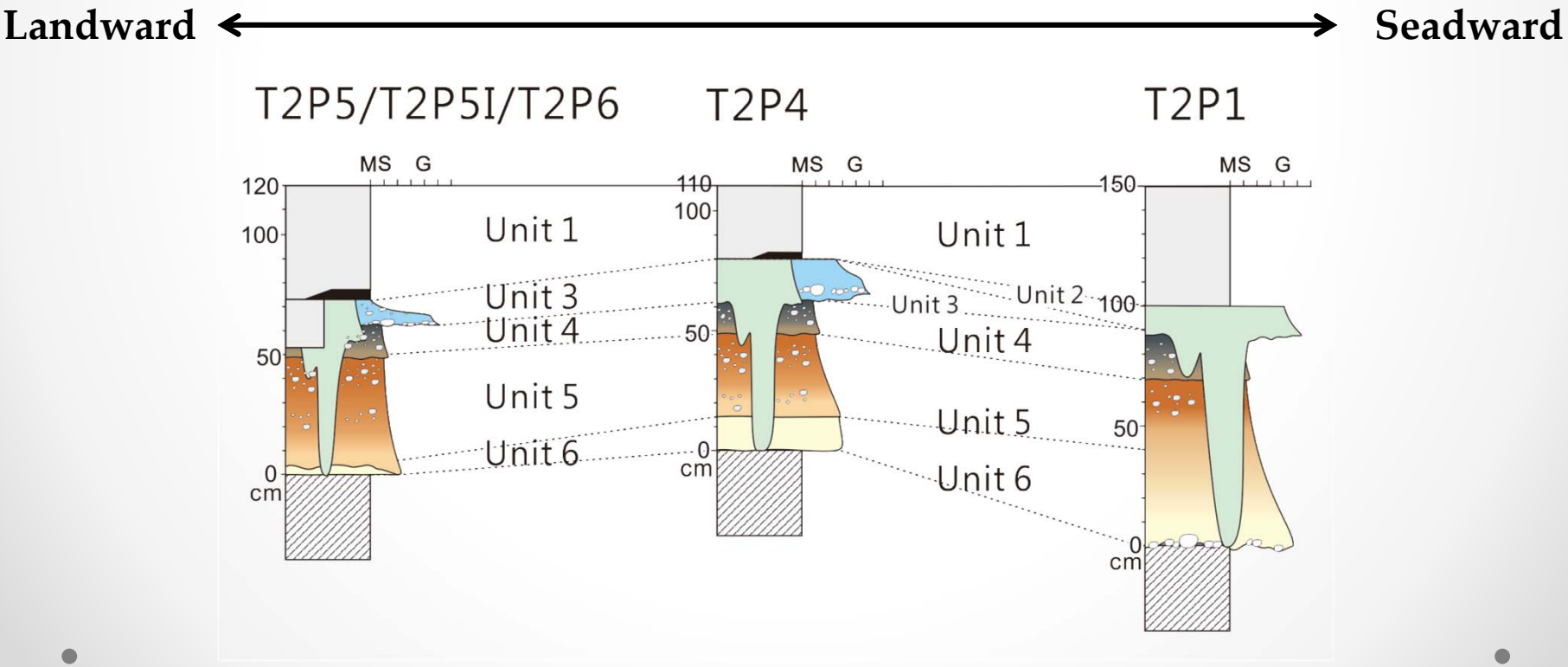




T2P1

Correlation

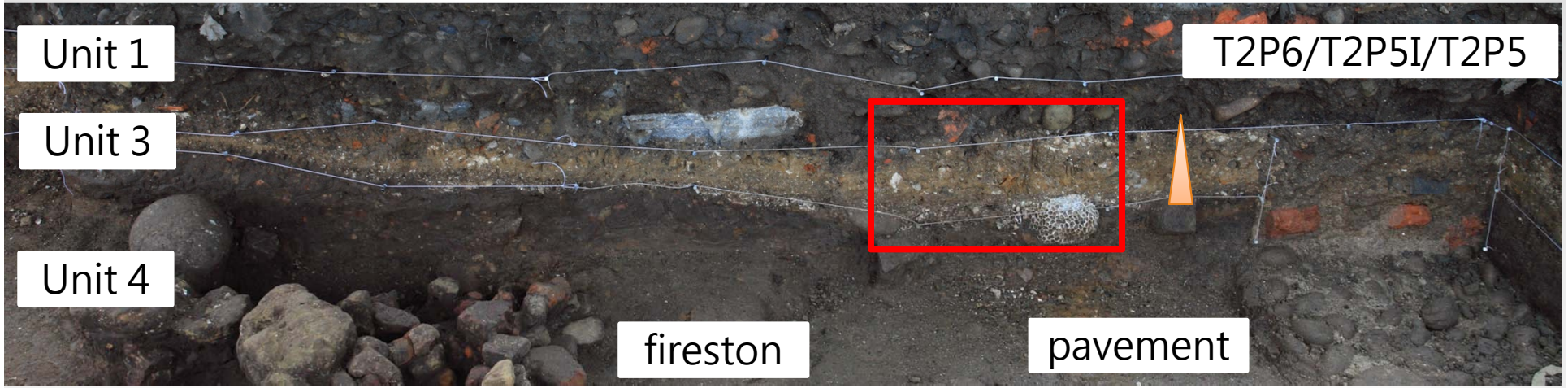
- The Unit 3 is pinch out from seaward to landward

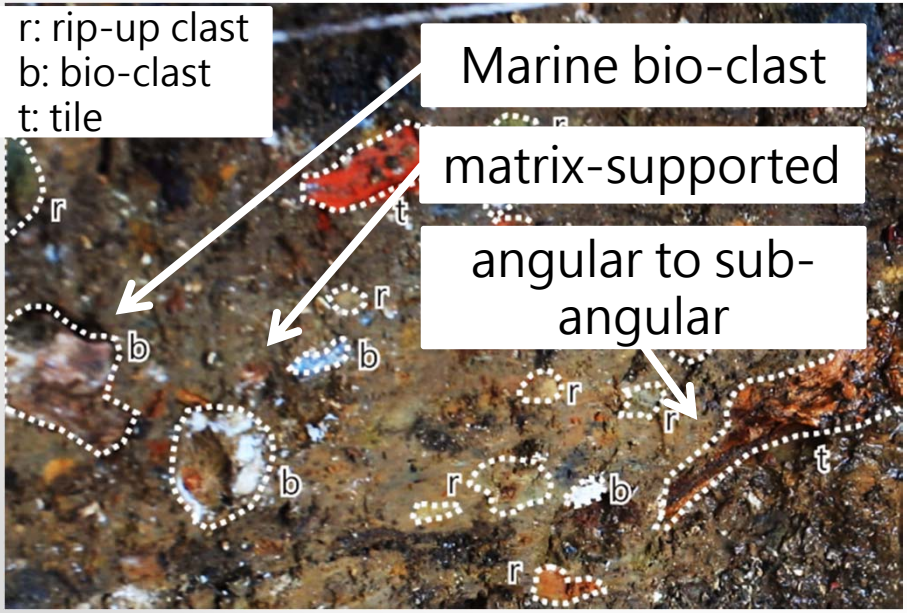


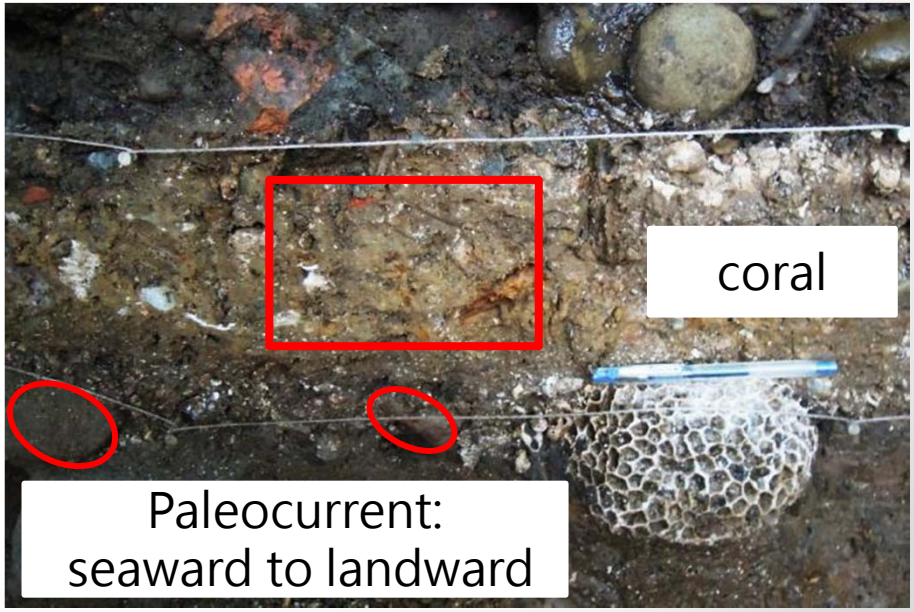
Sedimentary texture of Unit 3

landward

seaward



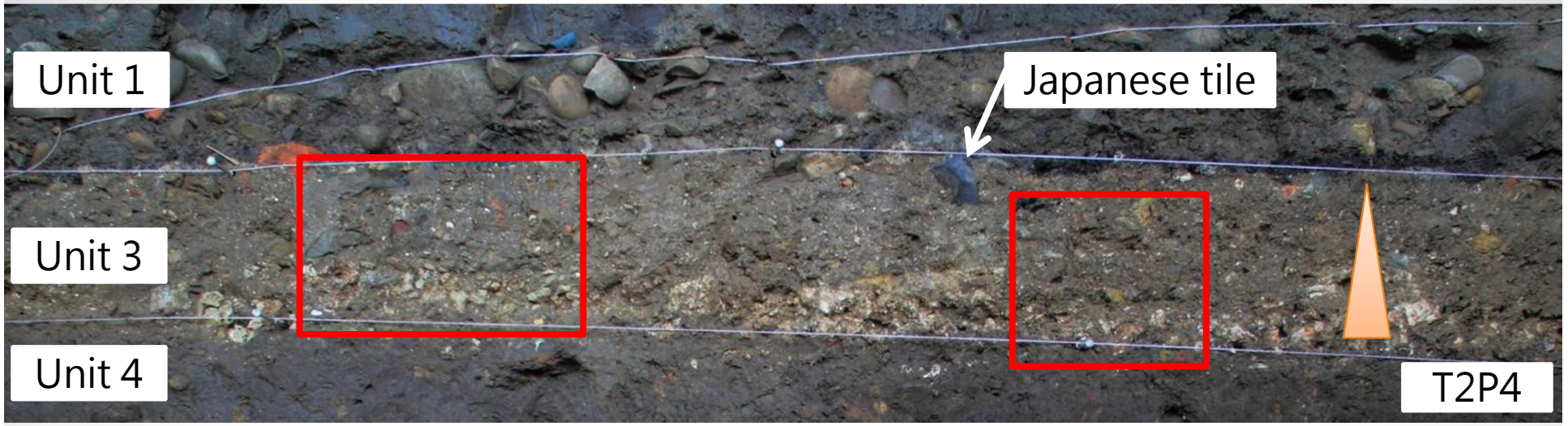


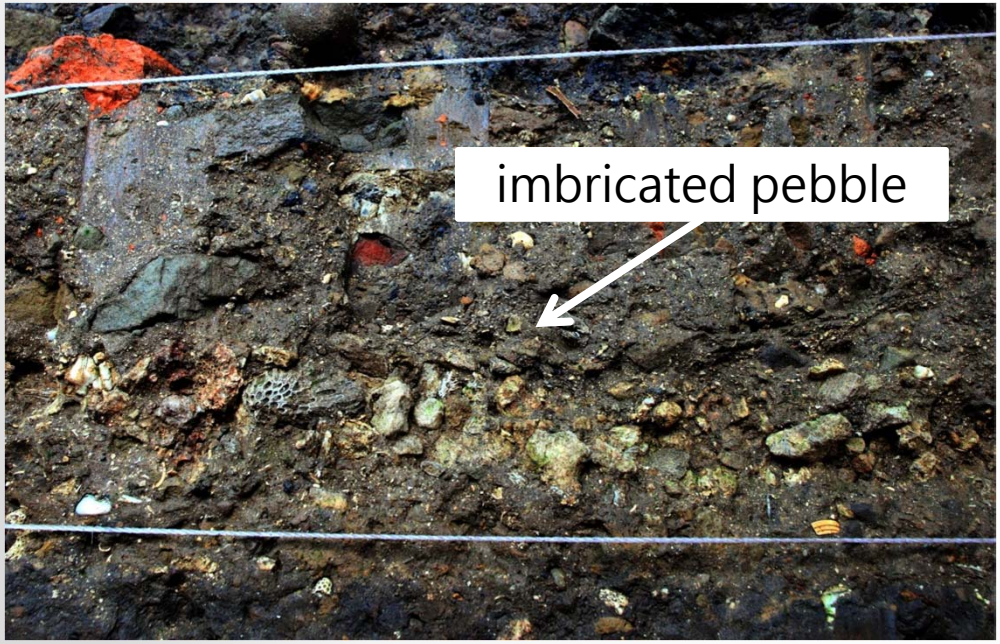


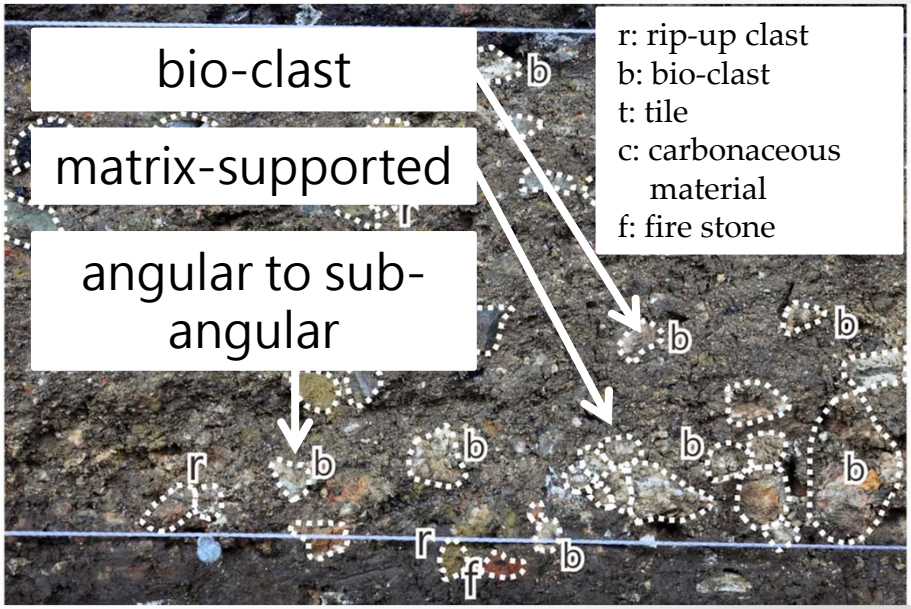
Sedimentary texture of Unit 3

landward

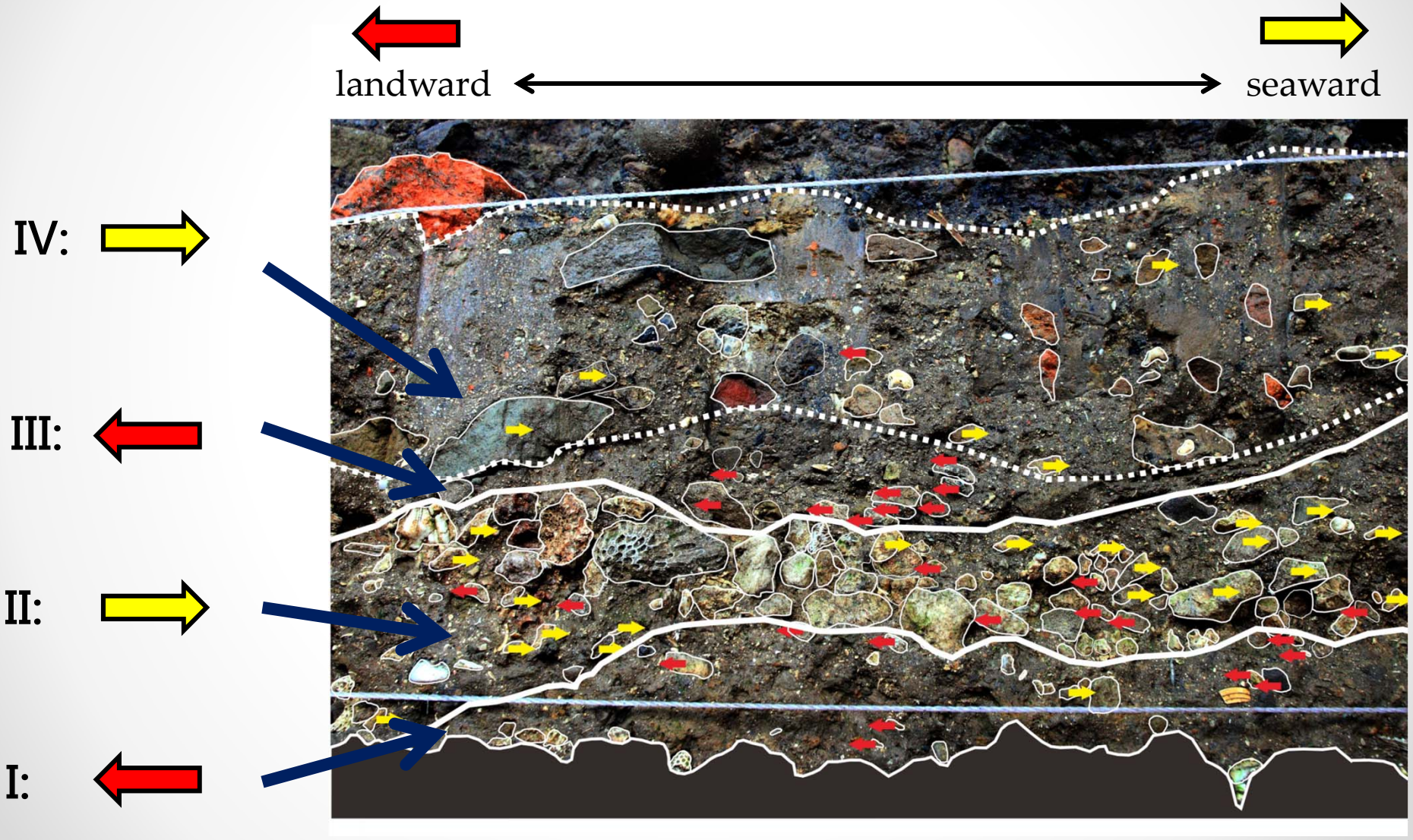
seaward



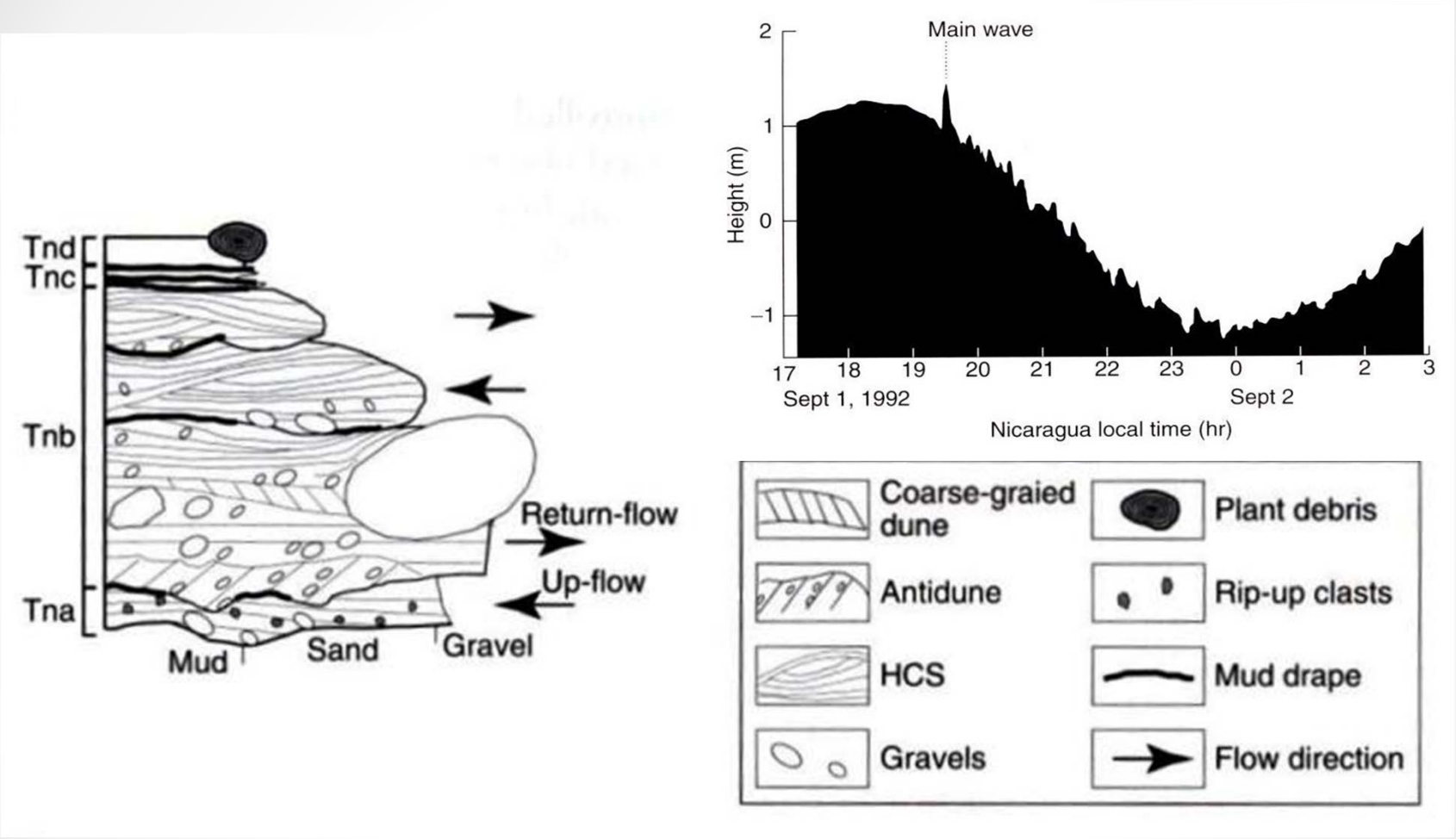




Sublayer and imbrication of Unit 3



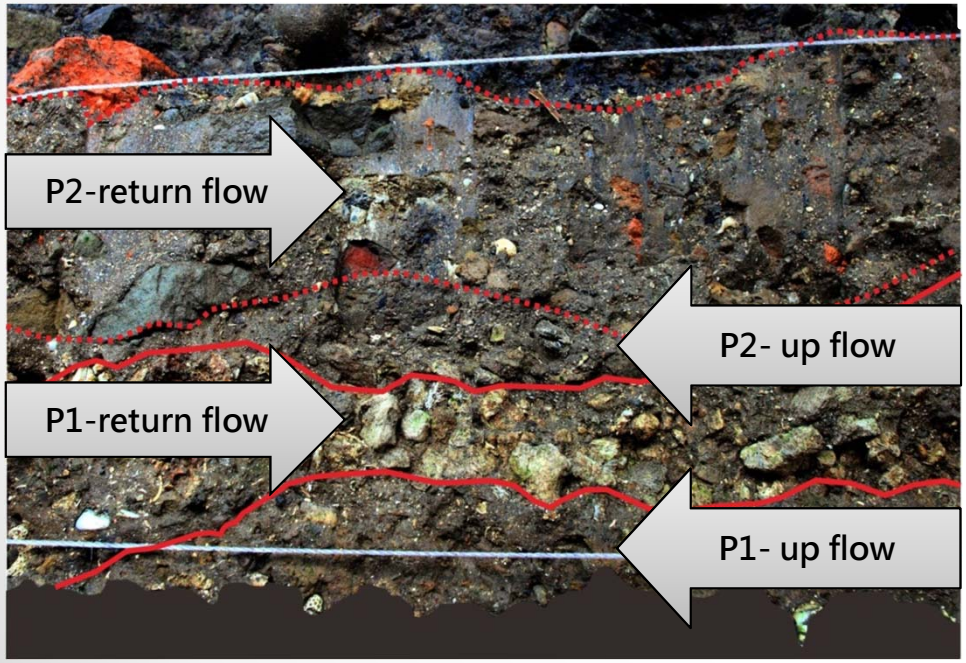
Facies model

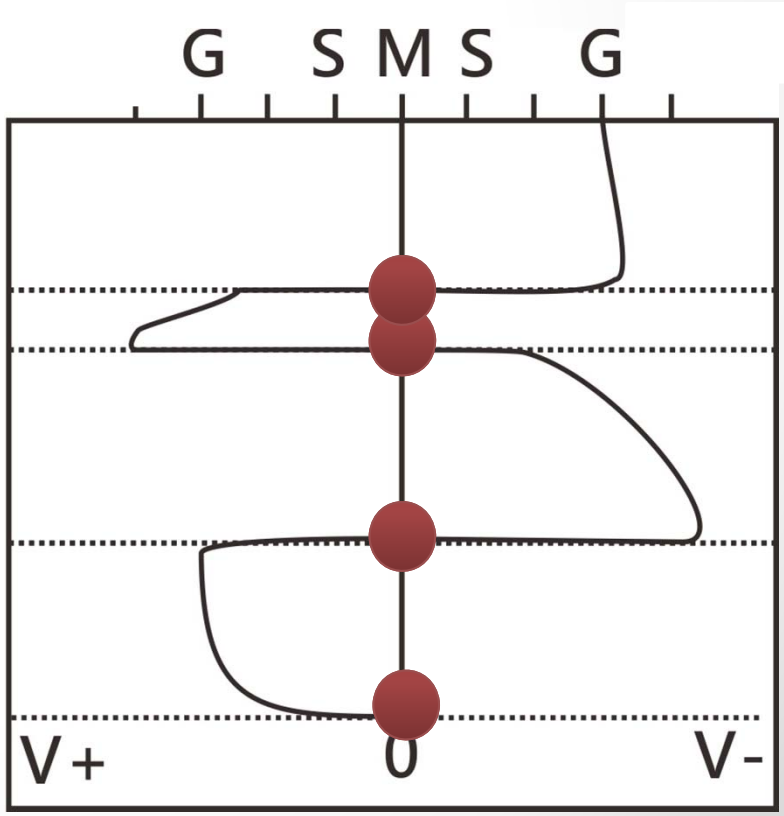


Reference： Higman, B. and Bourgeois, J. (2008) Deposit of the Nicaragua sunami. In :Tsunamiites – Features and Implications, Edited by Shiki, T., Tsuji, T., Yamazaki, T., Minoura, K., first edition, p81-103.

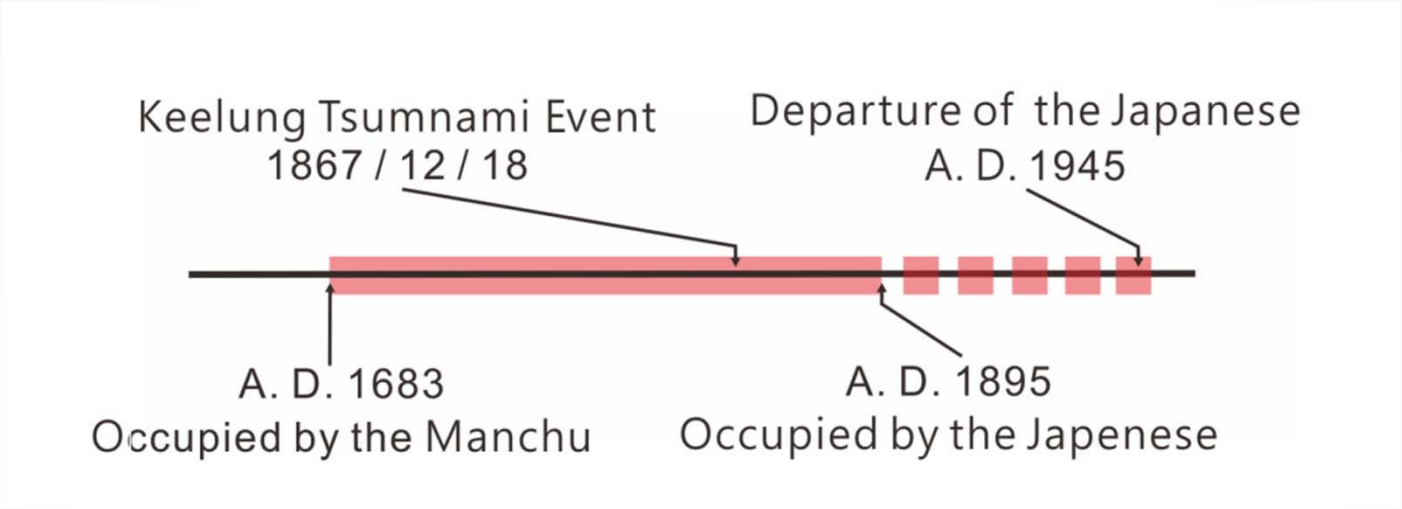
Fujiwra, O. (2008) Bedforms and sedimentary structures characterizing tsunami deposits. In :Tsunamiites -Features and Implications, Edited by Shiki, T., Tsuji, T., Yamazaki, T., Minoura, K., first edition, p51-62.

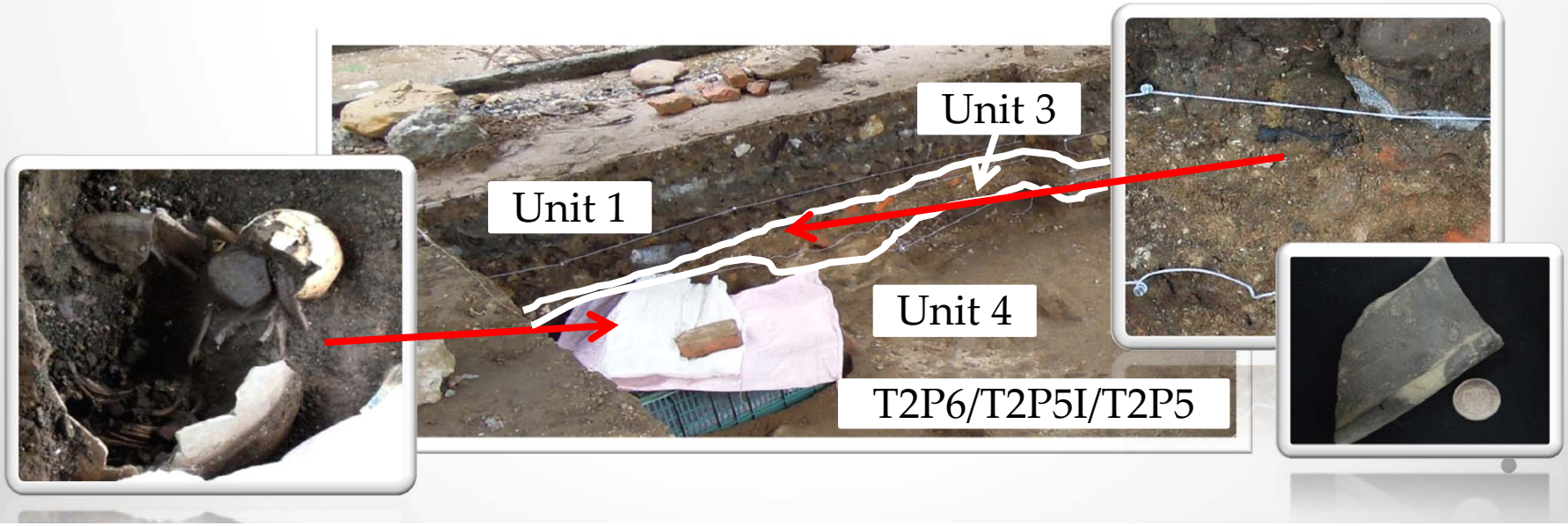

T2P4
landward
seaward


P2-return flow
P2- up flow
P1-return flow
P1- up flow


G
S
M
S
G
V+
0
V-

Age of the tsunami deposits, Unit 3





Conclusion

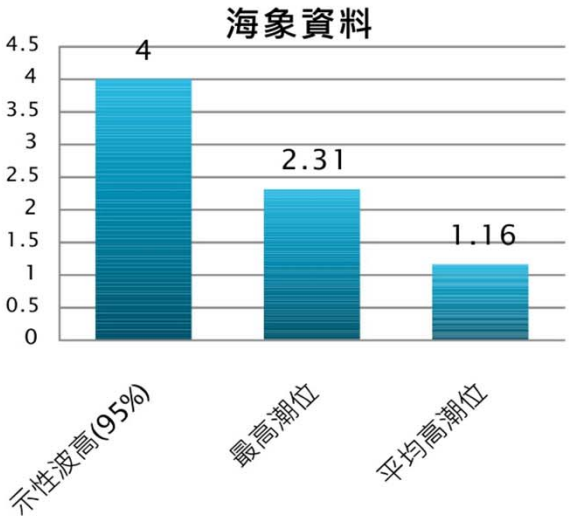
- According to sedimentary facies and composition, Unit 3 was deposited by marine process which is high concentration flow .
- By the result of facies analysis, Unit 3 is a deposits of tsunami event.
- Base on Japanese tile and Manchu jar, we correlate Unit 3 with Keelung Tsunami Event.

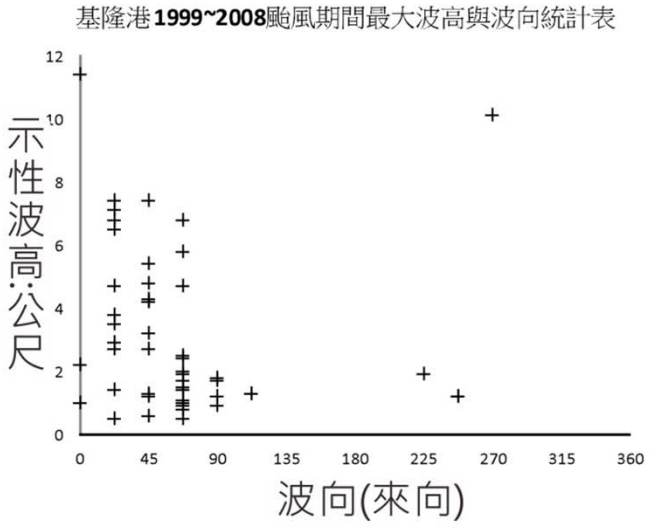
Thank you !

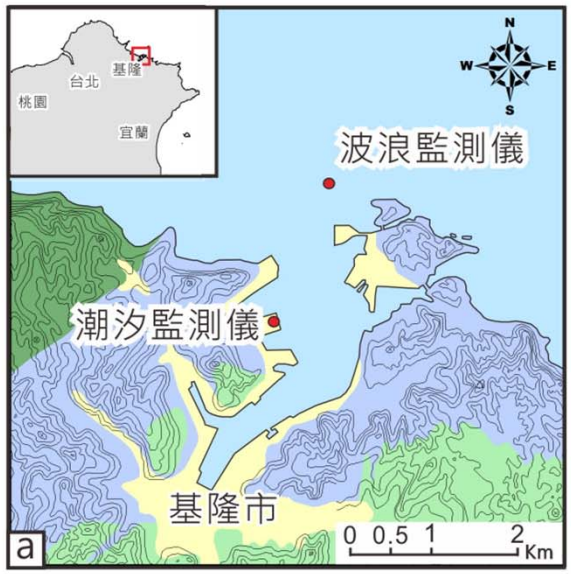
沉積模式比對

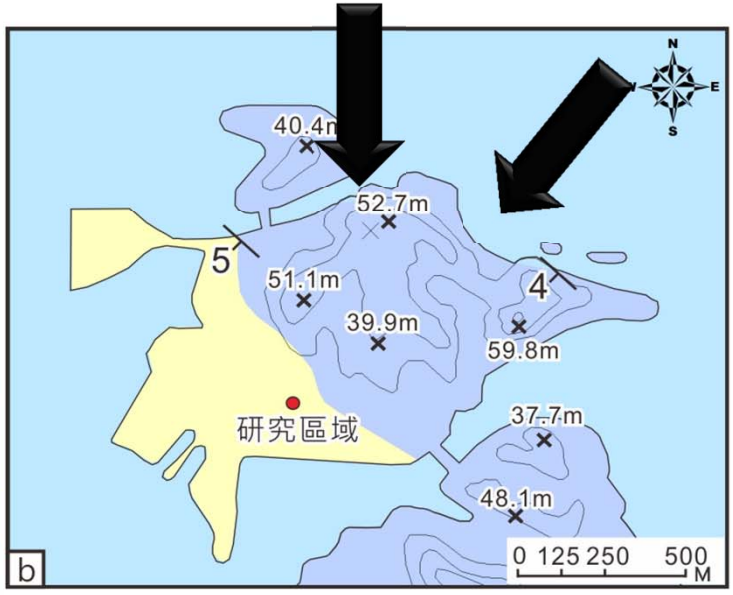
海嘯層特徵\海嘯	Fujiwra (2008)	本研究
沉積序列	向上變細	向上變細
岩層垂直接觸狀況	侵蝕性接觸，具有泥帶	侵蝕性接觸
沉積物組織成熟度	成熟度低	成熟度低
古水流	具有多次的海水上湧與回退	具有多次的海水上湧與回退

基隆港的海象資料


海象資料
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
4
2.31
1.16
示性波高(95%)
最高潮位
平均高潮位

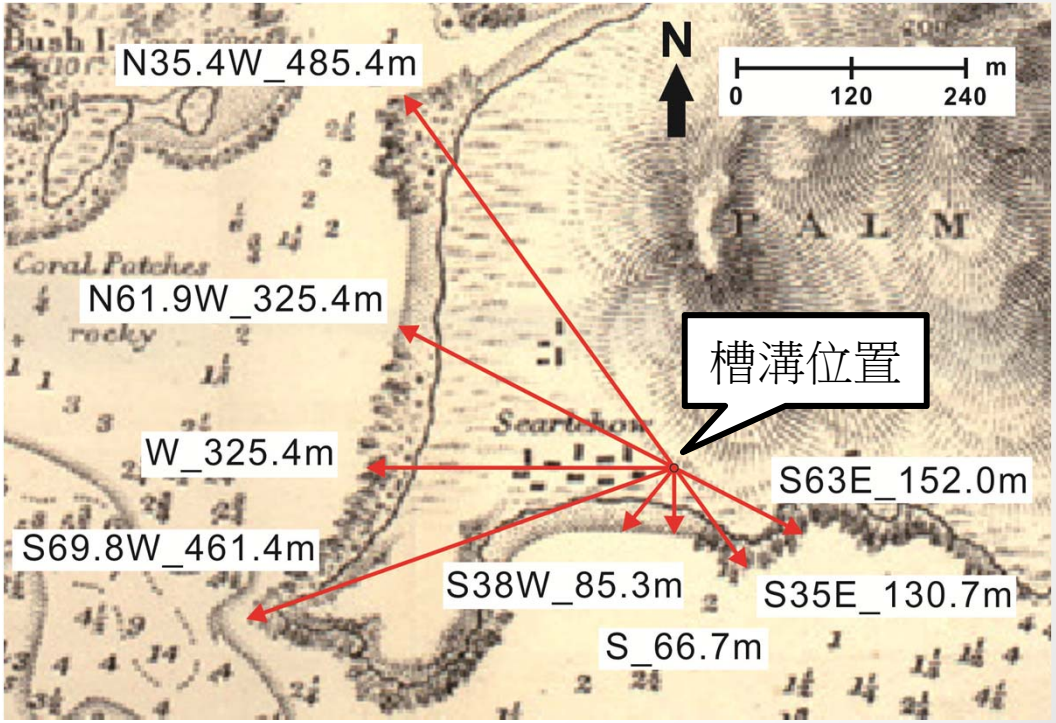

基隆港1999~2008颱風期間最大波高與波向統計表
示性波高:公尺
12
10
8
6
4
2
0
0
45
90
135
180
225
270
315
360
波向(來向)


台北
基隆
桃園
宜蘭
N
W
E
S
波浪監測儀
潮汐監測儀
基隆市
0 0.5 1 2 Km
a


N
W
E
S
40.4m
52.7m
5
51.1m
4
39.9m
59.8m
研究區域
37.7m
48.1m
0 125 250 500 M
b

1858年基隆港航海圖

1858年航海圖

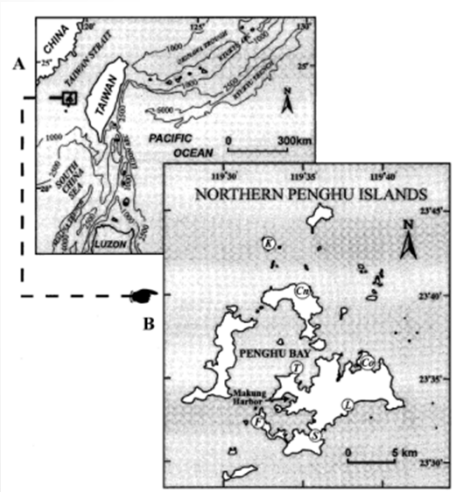


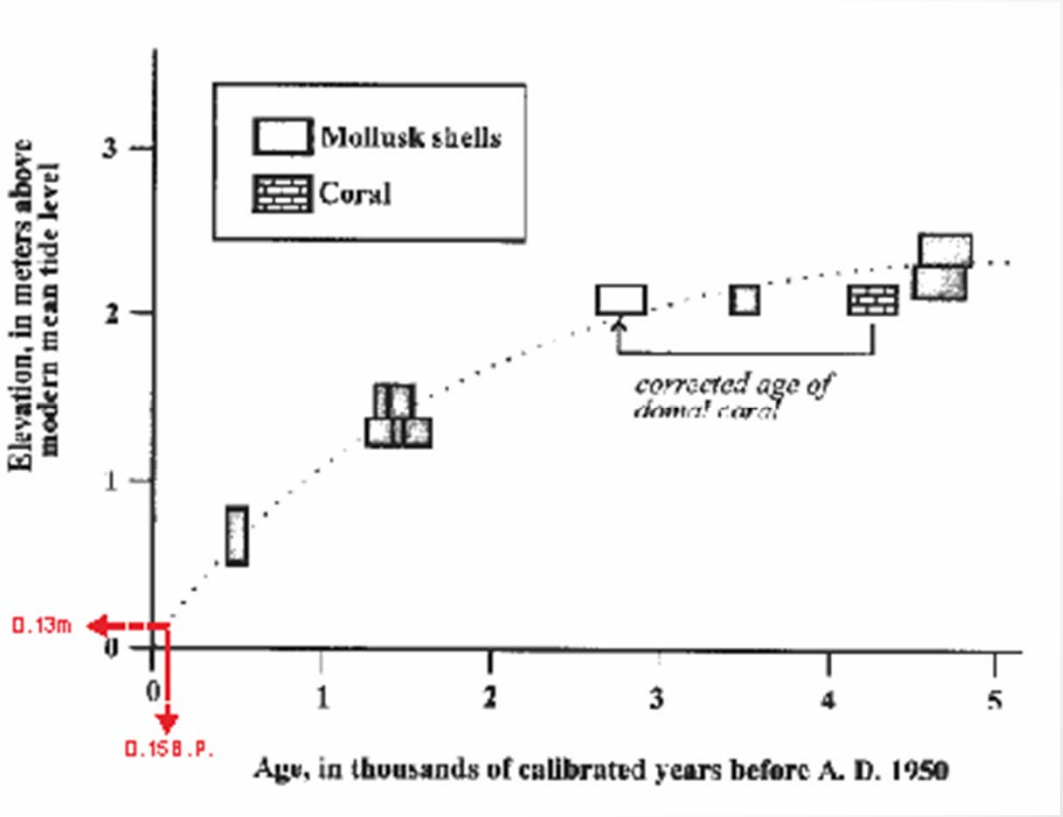
參考資料：

Blakeney, W. (1902) On the coasts of Cathay and Cipango forty years ago -a record of surveying servicein the China Yellow and Japanseas and on the seaboardof Korea and Manchuria. Elliot Stock, 353p.

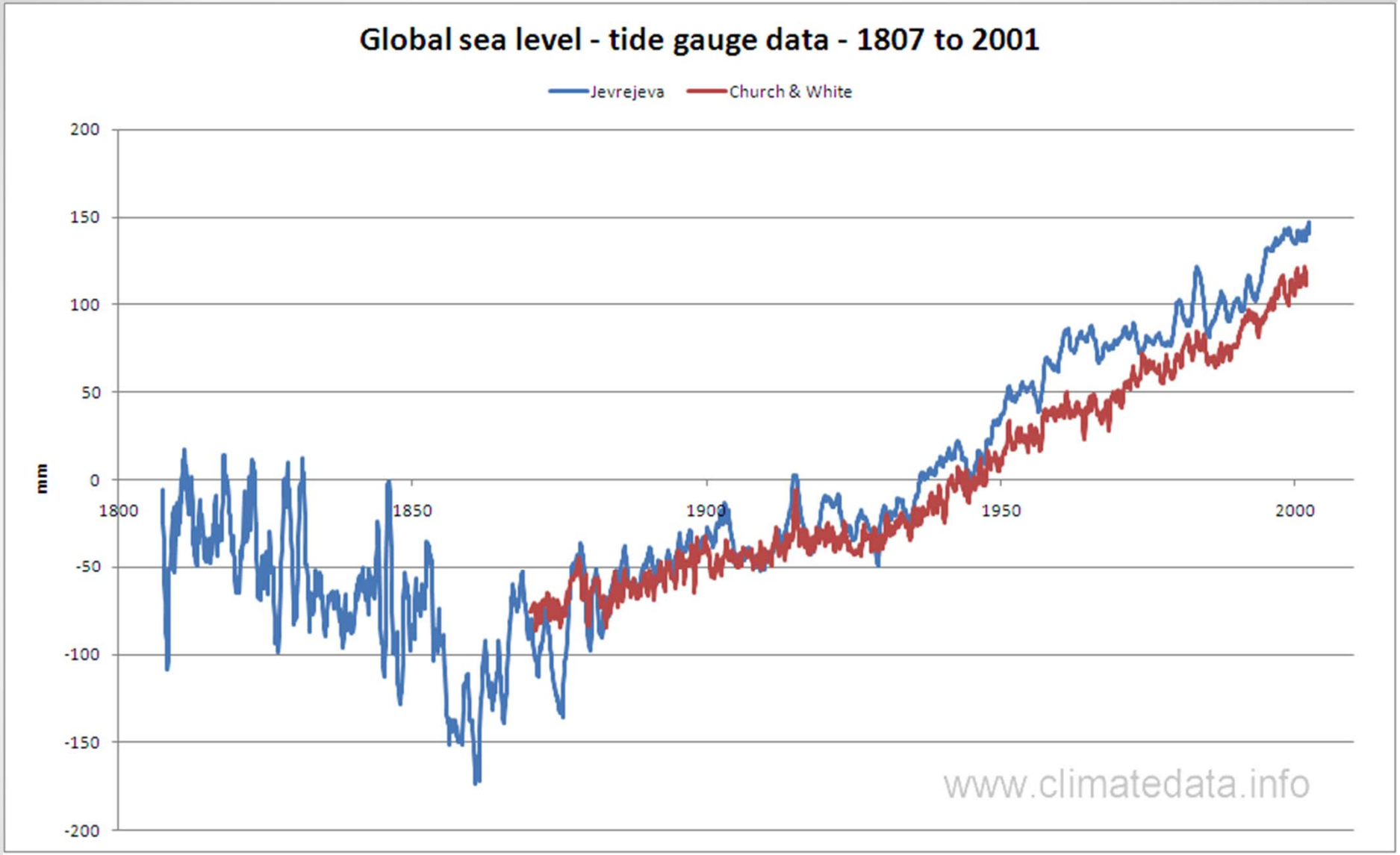
海水面變動

- 1867年海水面比現今高出0.13m





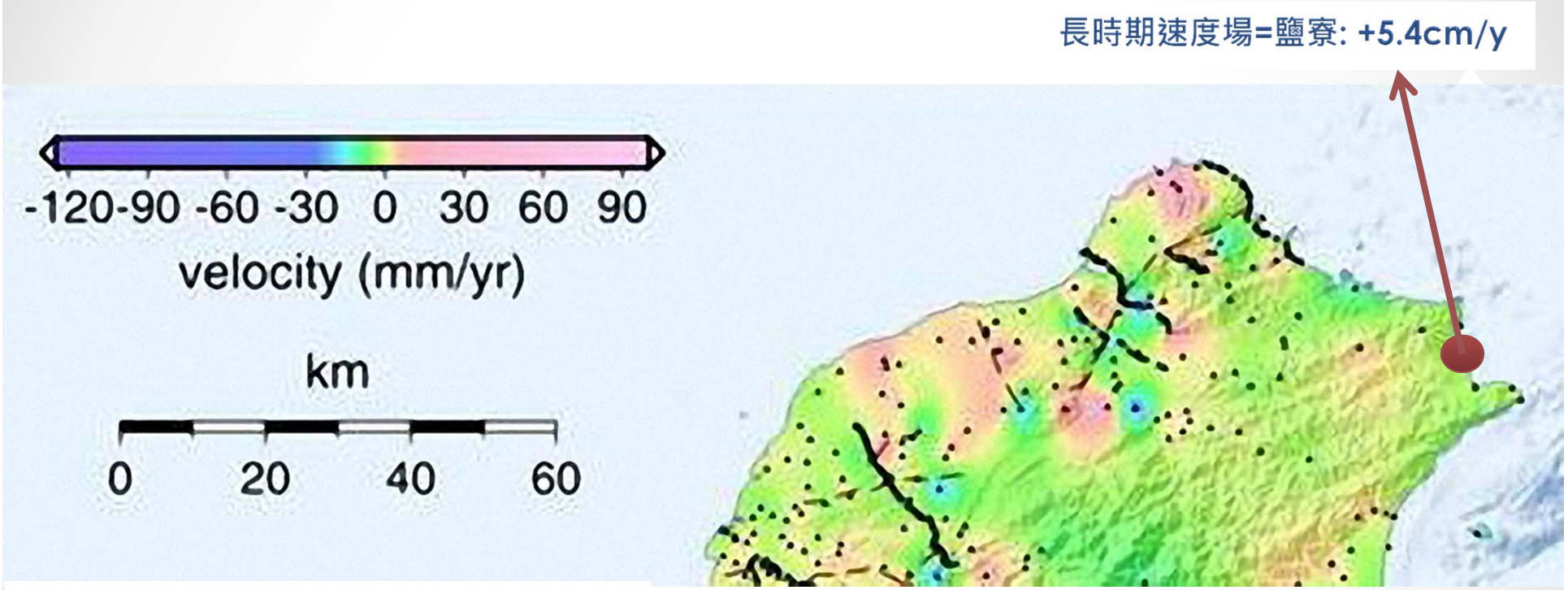
Chen, Y. G. and Liu, T. K. (1996) Sea Level Changes in the Last Several Thousand Years, Penghu Islands, Taiwan Strait. Quaternary research, 45, p254-262



參考資料： Jevrejeva, S., A. Grinsted, J. C. Moore, and S. Holgate (2006), "Nonlinear trends and multiyear cycles in sea level records", J. Geophys. Res., 111.

Church, J. A., and N. J. White (2006), A 20th century acceleration in global sea-level rise", Geophys. Res. Lett., 33

長期及短期之地殼變動

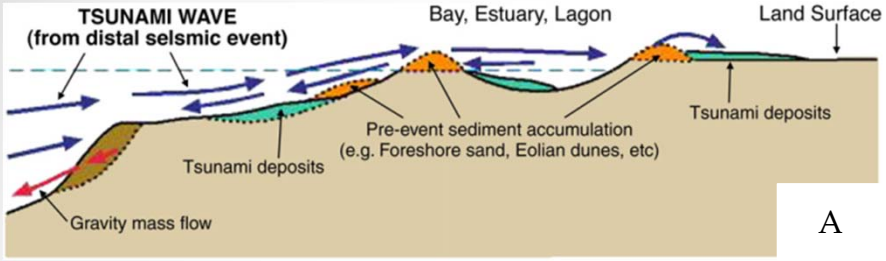


2002-2009年垂直速度場
GPS移動站/連續站/水準測量
(相對於澎湖S01R)

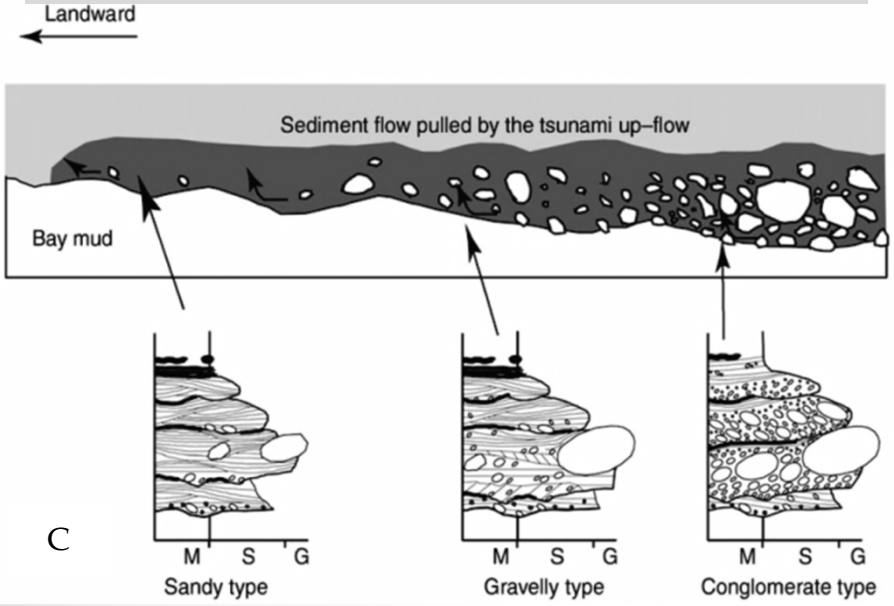
參考資料：饒瑞鈞、李元希、胡植慶(2009)地震地質與地變動潛勢分析地變動監測分析（3/4)。經濟部中央地質調查所，共400頁。

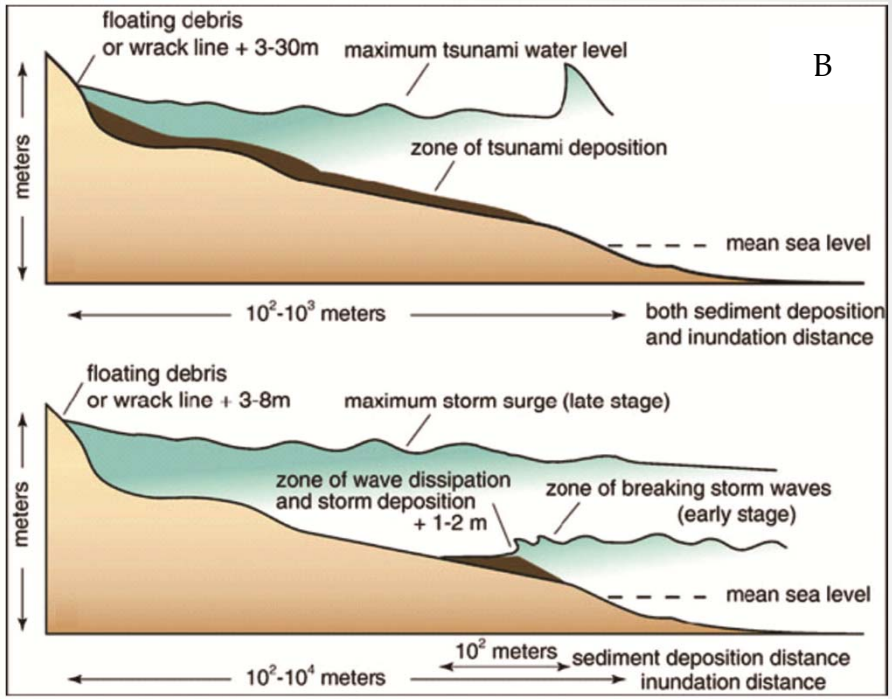
Song, S. R., Liu, C. M., Chen, C. W. and Lo, W. (2004) Pumice layers in marine terraces:implications for tectonic uplift rates on the east and northeast coasts of Taiwan over the last hundreds of years. Quaternary International, 115-116, p83-92.

海嘯沉積物的特性



受控於古地理型態-連續或不連續沉積





堆積在相對高及內陸的位置

沉積物在垂直與側向上變薄變細
沉積物指示run up 以及 back flow
在run up 與 back flow 間沉積mud drap

A：Dawson, A. G. and Stewart, I (2007) Tsunami deposits in the geological record. Sedimentary Geology, 200, p166-183.

B：Morton, R. A., Gelfenbaum, G. and Jaffe, B. E. (2007) Physical criteria for distinguishing sandy tsunami and storm deposits using modern examples. Sedimentary Geology, 200, p184-207

C： Fujiwara , O. and Kamataki, T. (2007) Identification of tsunami deposits considering the tsunami waveform: An example of subaqueous tsunami deposits in Holocene shallow bay on southern Boso Peninsula, Central Japan. Sedimentary Geology, 200, p295-313.