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Vanuatu subduction zone

The **Vanuatu subduction zone** (previously called **New Hebrides subduction zone**) is currently one of the most active subduction zones on Earth, producing great earthquakes (magnitude 8.0 or greater), with potential for tsunami hazard to all coastlines of the Pacific Ocean.[2][3] There are active volcanoes associated with arc volcanism.

Geography

The zone includes most of the islands of Vanuatu , the Santa Cruz islands of the southern Solomon Islands,[4] and the Loyalty Islands. A number of ocean floor features are related to the zone, in particular the New Hebrides Trench (South New Hebridies Trench)[5] and the North New Hebrides Trench (Torres Trench) which is separated from the southern trench by the d'Entrecasteaux Ridge and the island of Espiritu Santo. The d'Entrecasteaux Ridge is at this point of intersection two parallel, east-west trending ridges that are 1 to 2 km (0.62 to 1.24 mi) above the surrounding abyssal plain.[6]

Geology

Shore based observations had characterised the islands of the volcanic arc as having typical lavas and being of early Miocene or younger in age.[7] More recently marine surveys have supplemented this limited sampling. Reef terraces mantle on Espiritu Santo and Malekula show rapid late Quaternary terrace uplift of between 0.2 to 0.6 cm/year (0.079 to 0.236 in/year).[7] It is known that the Torres Islands to the north west have had less uplift recently.[7]

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New Hebrides subduction zone

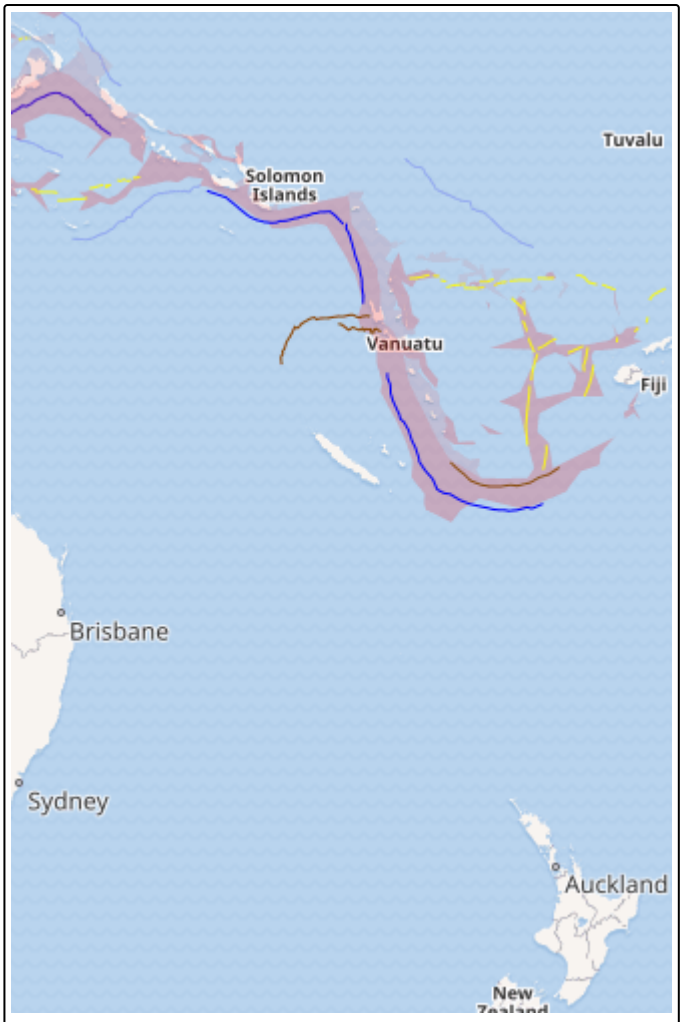
Off shore in the north it is known that the subducting plate has up to 1 km (0.62 mi) of sediments.[6]

The basalts of the d'Entrecasteaux Ridge, that are being subducted, are known to be between 56 and 21 million years old.[8][9] This material is lighter than the other subducted zone material except for West Torres Plateau material and this property is believed to be a factor in distortions of the island arc chain at these subduction points.[10] The rest of the oceanic basalt crust of the Australian plate that is being subducted otherwise is Eocene in age.[8] Beyond the Vanuata arc itself the bedrock of the North Fiji Basin is related to arc spreading centres, and some of the oceanic basalt is of recent origin.

There is classic arc andersite volcanism formed from calc-alkaline magma, in most of Vanuatu, but to the south where volcanoes are active in the Hunter Ridge the sampled lavas suggest magma generation involves contributions from adakitic, sediment and back arc-basin basalt (BABB) melt components.[11]

Tectonics

The zone defines the plate boundary between the New Hebrides microplate, which is related to the Pacific Plate, and the Australian Plate. Ten million years ago the Vanuatu island chain had an almost east west orientation with Fiji and the spreading centers of the North Fiji Basin have created both the current separation and quite different orientation.[12] The convergence rate in the subduction zone has a high rate of 170 mm (6.7 in)/year in the north at about latitude 11°S in the Solomon Island region, north of the Torres.[3] Where the d'Entrecasteaux Ridge is being subducted in the central section the convergence rate reduces to 40 mm (1.6 in)/year before increasing again to 120 mm (4.7 in)/year in the New Hebrides Trench east of the Loyalty Islands.[3] However at the d'Entrecasteaux

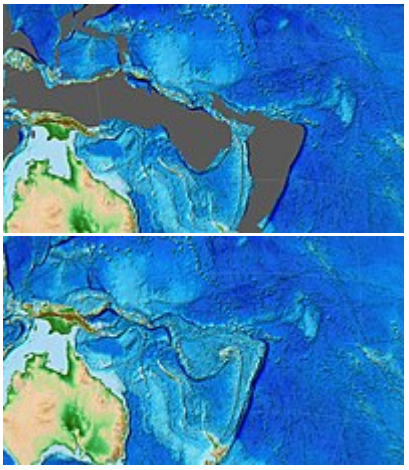


Approximate surface projection on Pacific Ocean of some tectonic features near Vanuatu subduction zone (center map). The New Britain subduction zone to the north is also shown. Key:
Up to 70 km (43 mi) deep shallow-focus earthquakes
70–300 km (43–186 mi) deep shallow-focus earthquakes
More than 300 km (190 mi) deep shallow-focus earthquakes
(blue) Active subduction trenches
(light blue) Inactive trenches
(brown) Selected oceanic floor ridges
(yellow) Spreading centers or rifts
Volcanoes and tectonic plate boundaries where they are transform faults are not shown. Mouse over shows feature names.

Etymology	Vanuatu
Tectonics	
Plate	Australian, New Hebrides
Status	Active
Earthquakes	Up to M_w8.2[1]

Ridge and Espiritu Santo central section there

Age	Miocene-current



Change in 12 million years to the present of south west Pacific region. At 12 Ma (top) what will become the Vanuata arc of islands is oriented east west with Fiji and the western Solomon Islands as the North Fiji Basin is yet to form. Grey areas represent now subducted ocean floor (disappeared in bottom picture).

is localized compression of 50 mm (2.0 in)/year in the volcanic back arc to compensate.[13] The ridge may have been subducting for up to the last two million years.[6]

Like the northern parts of the zone the southern subduction of the NW–SE trending Loyalty Ridge on the Australian plate under the southern Vanuatu microplates produces much earthquake activity.[3]

There has been asymmetric back-arc opening beyond the subduction zone in the North Fiji Basin and over the last 6 million years the Vanuatu chain has rotated about 28° clockwise.[10] There are two tectonic blocks related to Vanuatu in the basin separated by an extensional zone east of the island chain.[10]

The characteristics of the current active northward subduction of the South Fiji Basin under the New Hebrides Plate seems sufficiently different to the more northern subduction zone for some workers to have a different name and this region has been called the **Matthew and Hunter subduction system**, or **Matthew and Hunter subduction zone**.[14][15]

To the south subduction ceases at the triple junction with the Conway Reef Microplate under the North Fiji Basin with the rest of the convergence being accommodated by less tectonically active rifting in the western stretch of the New Hebrides Trench, the Hunter Ridge to its north and the Hunter Fracture Zone which is a transform faulting fracture zone continuation of the trench towards Fiji.[16] This triple junction is where from 3 million years ago the southernmost Central Spreading Ridge of the North Fiji Basin propagated southward and has now intersected with the New Hebrides Trench and the Hunter Fracture Zone.[16]

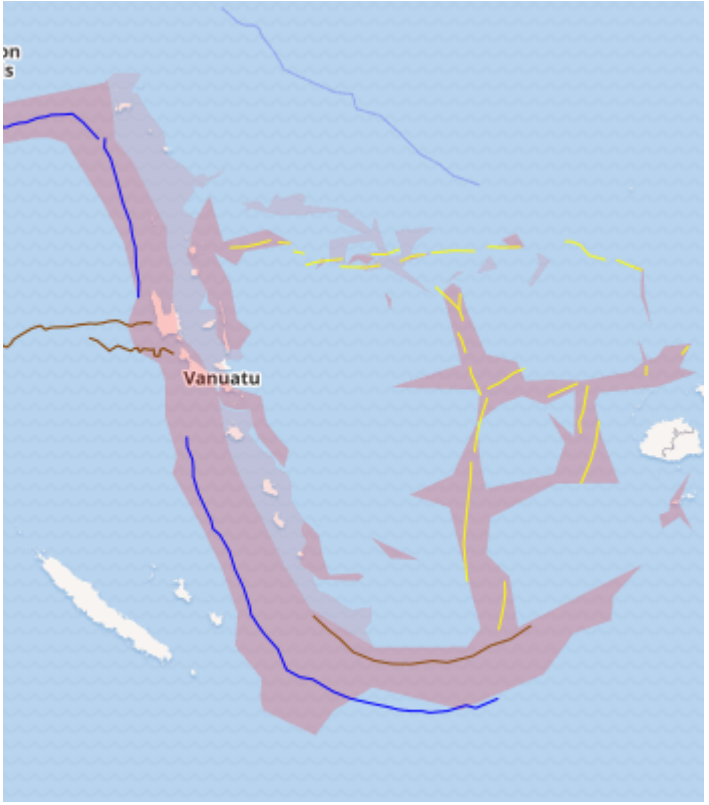
The progressive subduction/collision of the NW–SE trending Loyalty Ridge located on the Australian plate under the southern Vanuatu microplates produces much earthquake activity[3] but the most southernmost part of the trench south of latitude 22.5° S and east of longitude 170° E is not highly tectonically active[2] and translates into the non subducting Hunter Fracture Zone which is a transform faulting fracture zone.[16]

Seismicity

The subduction zone must have had many significant earthquakes but was isolated from historical records until the last 19th century. Even then the tsunami risk of these earthquakes to distant coastlines was not appreciated as most such earthquakes do not cause significant disruption of the sea floor.[2] The shallow and deep earthquakes associated with subduction of the Australian Plate slab are confined to an area about 150 km (93 mi) wide.[13] There are however other tectonic earthquakes associated with local plate boundaries nearby, as the North Fiji Basin has both spreading centres and fault zones and the most active parts are shown on a map on this page.

Earthquake "doublet"s have been well described in the zone and an example of two earthquakes greater than M_w7.7 occurred within 15 minutes of each other in the northern part of the zone on 7 October 2009.[13]

Strike slip earthquakes can occur associated with the subduction of the D'Entrecasteaux ridge.[13]



Approximate surface projection on Pacific Ocean of tectonic earthquakes near Vanuatu subduction zone and North Fiji Basin. Key is as for other map on this page. Active transform faults are not shown. Mouse over shows feature names.

The seismicity of the area of the southern part of the subduction zone between the latitudes 21.5 and 22.5° S and the longitudes 169 and 170° E is high.[3] There have been multiple earthquakes including swarms of magnitude M_w7.0 or more impacting on New Caledonia and Vanuatu.[3] The strain accumulation is regularly partially released through moderate to strong earthquakes during sequences which have included both interplate thrust faulting earthquakes and outer rise normal faulting earthquakes west and south-west of the trench.[3]

The M_w7.7 2021 Loyalty Islands earthquake (Matthew Island earthquake) was much stronger than the usual seismicity on the southernmost aspects of the New Hebrides Trench.[17] The epicenter was close to Matthew Island, to the north of the trench and was both preceded and followed by a seismic crisis of multiple events with greater than M_w5.0[17]

The table below shows only historic earthquakes greater than M_w7.5.[18][1] Other significant earthquakes may be found in the list of earthquakes in Vanuatu, list of earthquakes in the Solomon Islands archipelago and New Hebrides Trench articles.

Earthquakes greater than M_W7.5 in Vanuatu subduction zone

Date	Location	Magnitude (M_W)	Depth	Notes
1875-03-28	Loyalty Islands	8.1-8.2	-	[1]
1901-08-09	Tadine, New Caledonia	7.9	-	[3]
1910-06-16	28 km (17 mi) ESE of Isangel, Vanuatu	7.8	100 km (62 mi)	[18]
1920-09-20	97 km (60 mi) WSW of Isangel, Vanuatu	7.9	25 km (16 mi)	[1][18]
1928-03-16	274 km (170 mi) ESE of Tadine, New Caledonia	7.6	10 km (6.2 mi)	[18]
1934-07-18	138 km (86 mi) SSE of Lata, Solomon Islands 11°55′S 166°44′W	7.7	10 km (6.2 mi)	[19][18]
1950-12-02	99 km (62 mi) SW of Port-Vila, Vanuatu	7.9	30 km (19 mi)	[3][18]
1957-12-17	186 km (116 mi) NNW of Sola, Vanuatu	7.8	123.6 km (76.8 mi)	[18]
1965-05-12	52 km (32 mi) ENE of Port-Olry, Vanuatu	7.7	120 km (75 mi)	[18]
1965-08-11	38 km (24 mi) SSW of Port-Olry, Vanuatu	7.6	30 km (19 mi)	[3][18]
1966-12-31	172 km (107 mi) SSE of Lata, Solomon Islands11°53′S 166°26′W	7.8	55 km (34 mi)	[19][18]
1973-12-28	81 km (50 mi) NW of Port-Olry, Vanuatu	7.5	26 km (16 mi)	[18]
1980-07-08	196 km (122 mi) SEE of Lata, Solomon Islands	7.5	33 km (21 mi)	[18]
1980-07-17	199 km (124 mi) S of Lata, Solomon Islands	7.9	33 km (21 mi)	[18]
1995-05-16	249 km (155 mi) E of Vao, New Caledona	7.7	33 km (21 mi)	[18]
1997-04-21	171 km (106 mi) NNW of Sola, Vanuatu	7.7	33 km (21 mi)	[18]
1998-01-04	SE of Loyalty Islands	7.5	100.6 km (62.5 mi)	[18]
1999-11-26	92 km (57 mi) ESE of Lakatoro, Vanuatu	7.5	33 km (21 mi)	[18]
2009-10-07	148 km (92 mi) NW of Sola, Vanuatu	7.7	45 km (28 mi)	2009 Vanuatu earthquakes[3][18]
2009-10-07	196 km (122 mi) NW of Sola, Vanuatu	7.8	35 km (22 mi)	2009 Vanuatu earthquakes[3][18]
2013-02-06	75 km (47 mi) W of Lata, Solomon Islands 10°44′17″S 165°08′17″W	8.0	24 km (15 mi)	2013 Solomon Islands earthquake (Santa Cruz Islands earthquake)[19][3][18]

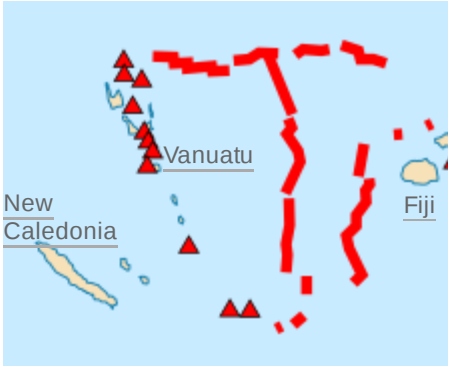
2018-12-05	116 km (72 mi) ESE of Tadine, New Caledona	7.5	10 km (6.2 mi)	Characterised as normal faulting[18]
2021-02-10	SE of Loyalty Islands	7.7	10 km (6.2 mi)	2021 Loyalty Islands earthquake (Matthew Island earthquake)[20][18]
2023-05-19	339 km (211 mi) east of Isle of Pines, Loyalty Islands	7.7	18.1 km (11.2 mi)	Characterised as normal faulting[18]

Tsunami hazard

The tsunami resulting from the 2013 Solomon Islands earthquake was 1.5 m (4 ft 11 in) high at the town of Lata on Nendö in the Santa Cruz Islands and resulted in ten deaths.[19] It was modelled as a megathrust event having produced over 3 m (9.8 ft) of seafloor displacement but its position allowed attenuation by the Gilbert Islands of the wave that reached Hawaii.[19] However modelling of the smaller tsunami that resulted from the M_w7.7 2021 Loyalty Islands earthquake showed that other sea floor features could channel the tsunami from a larger M_w8.2 earthquake at the same location north south, resulting in potential waves 1.5 m (4 ft 11 in) high at Norfolk Island and 1 m (3 ft 3 in)high on the West Coast of New Zealand.[2]

Volcanism

There is current active arc volcanism. For example Mount Yasur a stratovolcano has been erupting almost continuously since at least 1774 and erupted in the first 6 months of 2023.[21] So did Epi and Ambae, which is Vanuatu's most voluminous active volcano.[22] In 2022 Ambrym and the Gaua volcanoes erupted.[22] The active volcanism of Matthew Island and Hunter Island to the south is not quite classic arc volcanism due to the complex tectonics in this south eastern portion of the zone.[23]



Map of nearby current volcanic activity including arc volcanism in the east of the Vanuatu subduction zone. Spreading centers in the back arc North Fiji Basin are shown as red lines.

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