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GENBUDO CAVE

JAPAN

UNESCO Global Geopark

Genbudo and two caves, which are the remnants of digging, where rocks were used for construction against natural disasters but are now preserved as a monument. (Photo: Noritaka Matsubara).

LOCATION WHERE GEOMAGNETIC REVERSED POLARITY WAS FIRST PROPOSED THROUGH STUDYING BASALTS.

Around 100 years ago, Motonori Matuyama first proposed geomagnetic reversal in Genbudo. This discovery greatly contributed to the subsequent advancement of earth science; for example, ocean-floor paleomagnetic stripes based on magnetic normal and reversed polarity intervals advanced model of plate tectonics in the late 1960s (Vine and Mattherws, 1963).

The age of the basalt was determined in 1966, and their geological mapping was completed in 1991. Good exposures in Genbudo Park are quarries worked before the designation of the natural monument. Hexagonal disks of their columns of basalt were used for river banks, fire walls, and house fences. Such findings are useful for educational purposes.

SITE 010

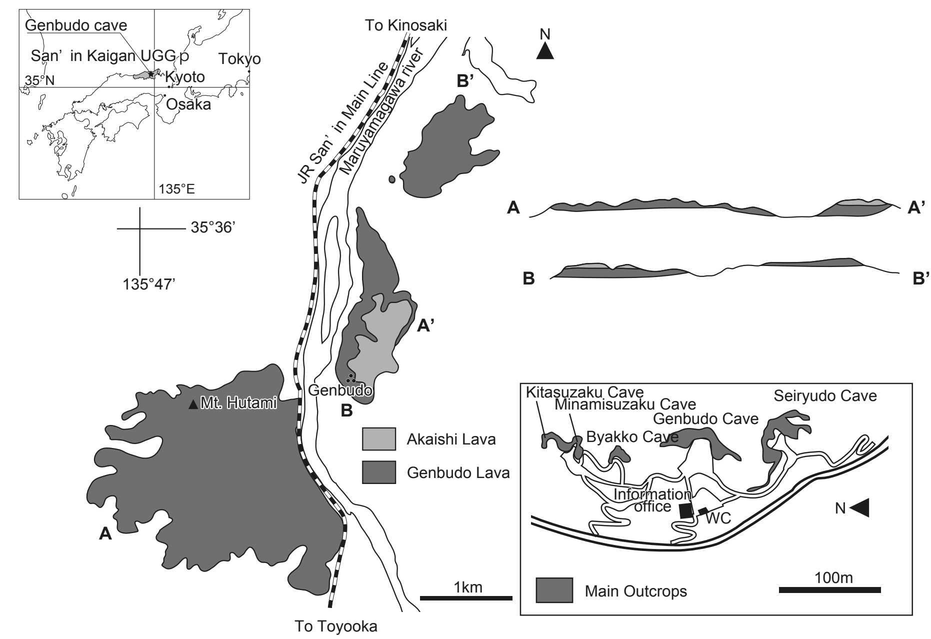
GEOLOGICAL PERIOD	Quaternary / Pleistocene
LOCATION	San'in Kaigan Geopark. Hyogo Prefecture. Japan. 35° 35' 17" N 134° 48' 18" E
MAIN GEOLOGICAL INTEREST	History of geosciences

Seiryudo Cave in the Genbudo Cave park, with its regularly but complexly oriented columnar jointing, is an excellent site for scientific research, education, and sightseeing. (Photo: Noritaka Matsubara).

Geological Description

Genbudo is one of the Quaternary Monogenic Basalt volcanoes in central Japan. The lava of Genbudo Cave is 1.61-Ma alkaline basalt (Genbudo Research Group, 1991; Kawai and Hirooka, 1966). It exhibits spectacular columnar jointing reflecting its complex cooling history. In 1926, Dr. Motonori Matuyama discovered that the basalt of Genbudo Cave exhibited magnetic polarity opposite to the present geomagnetic field. This discovery led to the recognition of the presence of a period of the earth's magnetic field opposite to the present, and in 1929, he proposed "geomagnetic reversal polarity" (Matuyama, 1929). The geomagnetically reversed period, including the age of Genbudo, was named "Matuyama Reversed Chron" in the 1960s, whose start corresponds to the beginning of Quaternary.

Ritsuzan Shibano, a Confucian scholar, visited Genbudo Cave in 1807 and named it Genbudo because he compared the outcrop's irregularly oriented columnar joints to a Chinese legendary animal, Genbu (black tortoise). In 1884, Koto Bunjiro named the basalt "Genbugan" in Japanese from Genbudo, whose Chinese characters are used also in China. In 1931, Genbudo Caves were designated as a national natural monument. Since then, they have been preserved and managed as educational sites, accessible only for research.



Geological Map around the Genbudo Cave Park. Five caves in the Genbudo Cave Park are the ruins of quarries.

Scientific research and tradition

Matuyama proposed the first geomagnetic reversal polarity approximately 100 years ago. The 2.58–0.774-Ma period was adopted as "Matuyama Reversed Chron" in the 1960s (Cox *et al.,* 1964). The Matuyama Reversal was established as the start of Quaternary (Head *et al.,* 2008).

NOJIMA FAULT

JAPAN

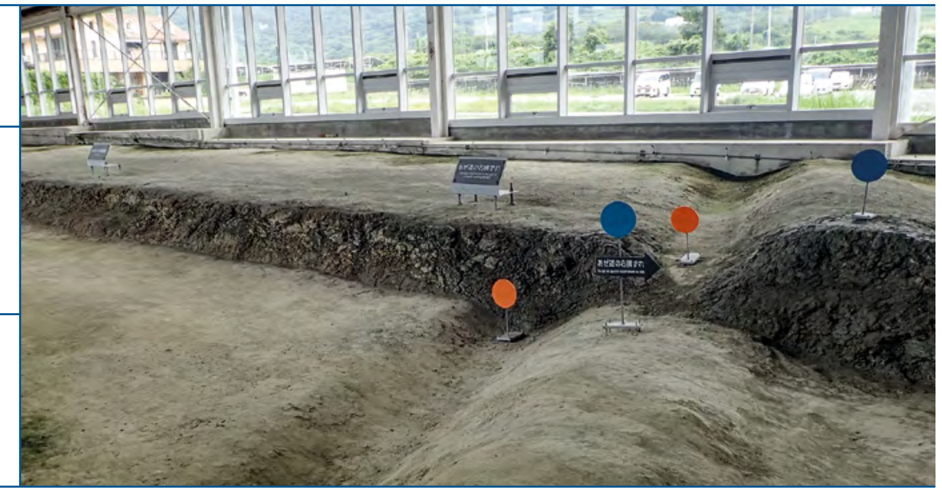
Northeastern section of the earthquake fault trench inside the Nojima Fault Preservation Pavilion in the Hokudan Earthquake Memorial Park. (Shigehiro Kato)

THE FAULT THAT CAUSED THE 1995 KOBE EARTHQUAKE.

"Earthquake fault" is a surface displacement that is important evidence of both the earthquake and the resultant disaster. The preservation of earthquake faults is extremely rare because they are soon flattened by landowners to recover their livelihoods in addition to the difficulty in conservation techniques and management. Fortunately, immediately after the Kobe Earthquake, the Nojima Fault was preserved for educational and research purposes, and the topography and damaged condition of this fault were preserved in the best way possible (Katoh, 2020). As in Taiwan, the technique and management methods developed here have become the standard for fault conservation.

SITE 074

GEOLOGICAL PERIOD	Quaternary Modern (1995)
LOCATION	Awaji City, Hyogo Prefecture, Japan 34° 32' 60" N 134° 56' 16" E
MAIN GEOLOGICAL INTEREST	Tectonics Geomorphology and active geological processes



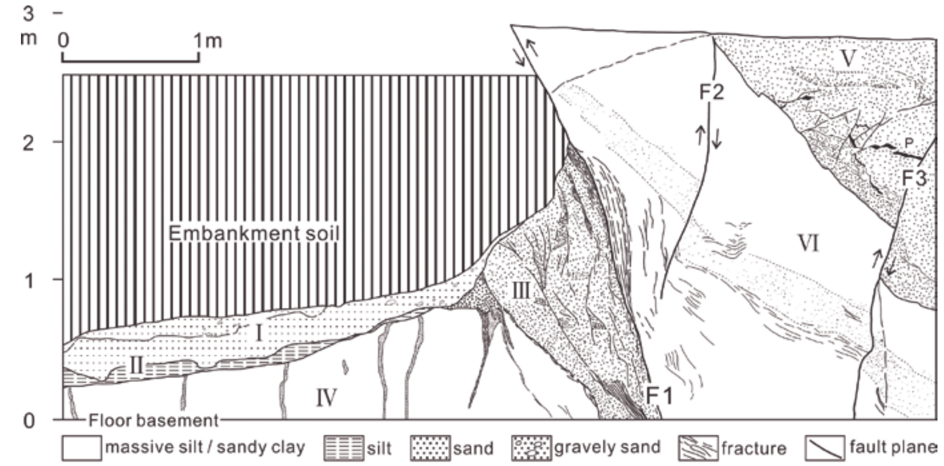
Right-lateral displacement of the earthquake fault in the Nojima Fault Preservation Pavilion. (Shigehiro Kato).

Geological Description

The Nojima Fault is an active fault that generated the "Hyogo-ken Nambu Earthquake" (Kobe Earthquake) (M7.3), which hit the southern part of Hyogo Prefecture, central Japan, on January 17, 1995, killing approximately 6,400 people (Ando *et al.*, 2001; Awata *et al.*, 1996). The fault extends northeastward, intermittently traceable on the surface, for a total length of approximately 9 km from Hokudan to Ichinomiya towns (both now Awaji City) in the northern part of Awaji Island. This is a reverse fault with a right-lateral strike-slip component, showing the maximum horizontal and vertical displacements of 2.1 and 1.2 m, respectively (Lin and Uda, 1996). The Nojima Fault is typically exposed for approximately 185-m long in Hokudan Town, with approximately four-fifths of it preserved in the building, Nojima Fault Preservation Pavilion of Awaji City, which is open to the public. A trench inside the building exhibits the cross section of the fault, which has a vertical displacement of 0.2–0.5 m that uplifted the southeast side with a right-lateral displacement of 0.7–1.5 m (Takemura *et al.*, 1998). The main fault and parallel-extending bifurcated fault with destroyed paved roads, displaced ridges, drainage channels, and forest hedges are preserved.

Scientific research and tradition

Rupture propagation along the Nojima Fault is discussed from detailed along-fault distributions of vertical and horizontal displacements. Based on trenching surveys and analysis of nearby drilling cores, the fault was reactivated many times during the late Quaternary with a recurrence interval of approximately 2000 years (Lin and Nishiwaki, 2019).



I and II: Late Pleistocene slope deposits, III: Liquefied sand, IV–VI: Early Pleistocene Osaka Group, F1: Earthquake fault plane and fracture zone, F2 and F3: Secondary fault planes. P: Peaty clay layer.

Sketch of the northeastern section of the earthquake trench inside the preservation pavilion.