

THE MINERALOGICAL SOCIETY  
OF AMERICA  
SHORT COURSE  
MINERALOGY AND GEOLOGY OF NATURAL ZEOLITES

Field Trip Guide, Olympic Peninsula  
Sunday, 6 November 1977

Introduction

This guide is a narrative designed to accompany a short field trip to occurrences of natural zeolites in the vicinity of Seattle, Washington. Bedrock exposures in Seattle are extremely limited because most of the area is underlain by a thick sequence of continental glacial deposits. Zeolites are very common, however, in both the Olympic and Cascade Mountains, where they typically occur as alteration products of volcanic and volcanoclastic rocks.

Our trip will take us to the Olympic Peninsula, where we will examine two occurrences of zeolites, one in altered basaltic volcanic rocks, and the second in a thick section of marine sedimentary rocks.

We will begin our trip by taking a short (approximately 45 minute) ride across Puget Sound on one of the ferries of the Washington State Ferry System. We will disembark in Bremerton, Washington (the site of a huge U.S. Navy shipyard, and where the battleship U.S.S. MISSOURI is permanently moored) and we will examine exposures of altered volcanic rocks of the Crescent Formation. Following a lunch break and a short ride we will examine one or two exposures of the Blakely Formation, a marine volcanoclastic sequence that contains abundant clinoptilolite. Our trip will end back in Seattle, following a second ride on one of the large "superferries".

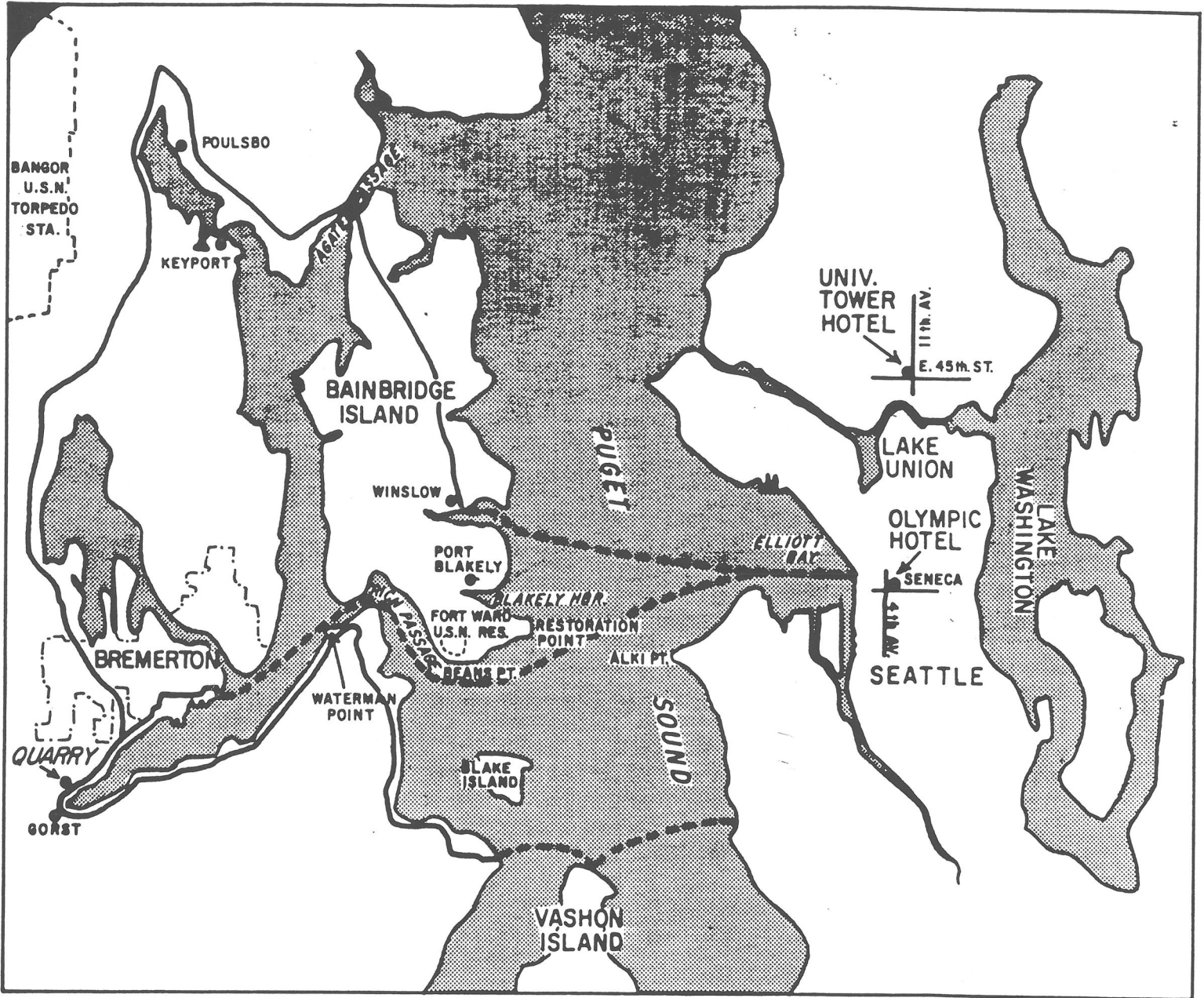
Rocks to be Examined

The Crescent Formation

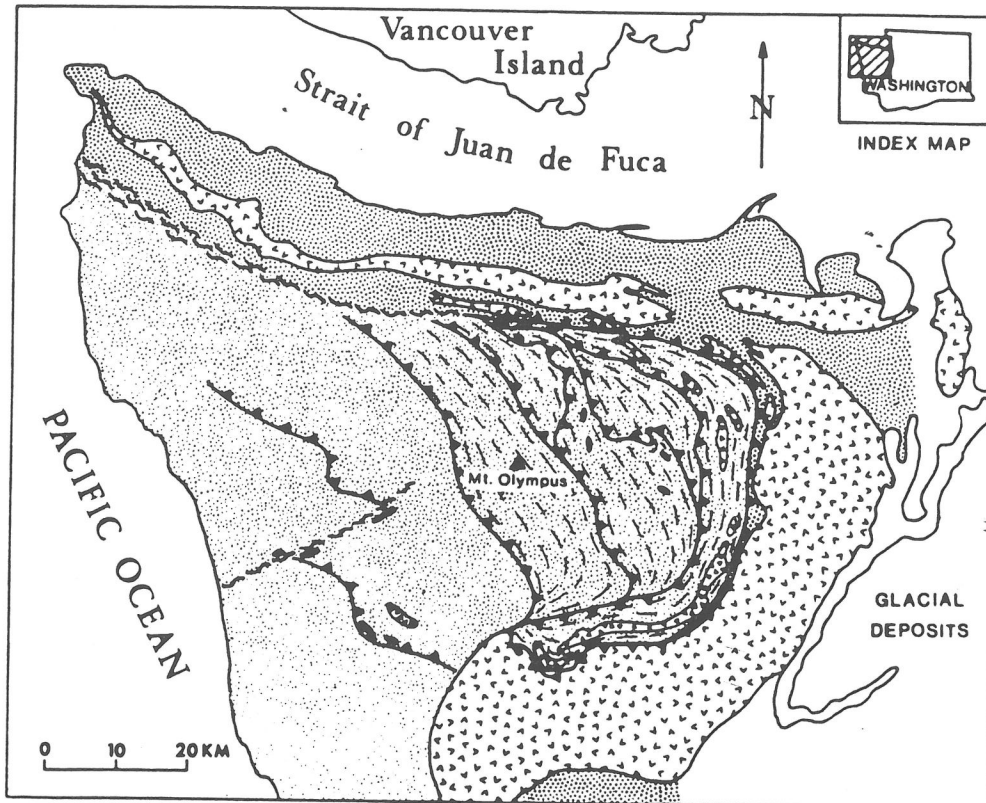
The Crescent Formation is a thick assemblage of mafic volcanic and volcanic clastic rocks of early and middle Eocene age. Exposures of rocks assigned to the Crescent extend along the northern and eastern Olympic Peninsula from Cape Flattery east and south well past Bremerton. To give you some feeling for the extent of the Crescent Formation, all of the Olympic Mountains visible from Seattle consist of volcanic rocks of the Crescent. The thickest section of basalt in the formation occurs about 30 miles north of Bremerton, where the Crescent has a thickness of about 15 kilometers.

Most of the rocks of the Crescent are basalts of oceanic tholeiitic composition. Extensive tongues and lenses of pillowed and massive flows thousands of feet thick and several miles long are common.

Virtually all of the rocks are submarine deposits, with the exception of some columnar-jointed flows found near the top of the formation.

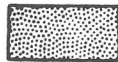


Map showing the route and localities to be visited on field trip to the Olympic Peninsula, Washington.



**MARGINAL FACIES**

*Orderly, moderately deformed and partially metamorphosed*



Eocene to Miocene sedimentary rocks



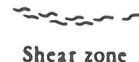
Early(?) and middle Eocene volcanic rocks  
*Crescent Formation as defined by Brown and others (1960)*



Contact



Thrust fault



Shear zone

**AXIAL FACIES**

*Intensely deformed, faulted, and partially metamorphosed*



Eocene to Miocene sedimentary rocks

*Dashed where penetratively deformed*



Eocene and younger(?) volcanic rocks  
*Basalt and greenstone*

Simplified geologic map of the Olympic Peninsula, Washington.

Associated with the basalts are some limited exposures of sedimentary rocks, chiefly sandstone, mudstone, and red limestone. The red limestones of the Crescent have been a subject of some interest for many years, because associated with them are small deposits of manganese. A number of zeolites and manganese minerals have been described from these deposits, and many of you are undoubtedly familiar with the work of Charles Park on the Crescent Formation and its manganese deposits done around 1940 for the Strategic Minerals Branch of the U.S. Geological Survey.

Most of the rocks of the Crescent are grayish green to black, except where oxidized, and contain clinopyroxene and labradorite in a matrix of brown glass or chlorite. Minerals in amygdules and veins include chlorite, calcite, and a number of zeolites. Many of the rocks have been altered and now are clinopyroxene-albite basalts with associated prehnite, pumpellyite, and epidote.

### The Blakely Formation

The Blakely Formation, exposed on the south shore of Bainbridge Island and on the north shore of the Kitsap Peninsula, consists of about 9000 feet of interbedded conglomerate, sandstone, and shale of Oligo-Miocene age. Based on its fossil content, all of it was deposited in a marine environment.

Poorly sorted, fine- to coarse-grained lithic and feldspathic tuffaceous sandstone is the dominant rock type in the formation. Smaller amounts of shale and conglomerate are interbedded with the sandstone. The framework grains in most rocks consist of subrounded fragments of plagioclase, andesite and basalt. Volcanic rock fragments are most abundant in conglomerate and pebbly sandstone, whereas plagioclase dominates in fine-grained sandstone and siltstone. Fragments of zeolitized pumice are abundant in coarse-grained sandstone and pebble conglomerate.

Common ancestry minerals in the rocks include augite, hornblende, quartz, biotite, and muscovite with minor amounts of sanidine and glauconite. Heavy minerals include magnetite-ilmenite, leucoxene, augite, hornblende, epidote, and sphene, with minor amounts of garnet, zircon, and apatite. Metamorphic rock fragments are restricted to the upper 1800 feet of the formation. Chloritized and albitized volcanic fragments, quartzite, and prehnite and quartz-bearing fragments are common.

Rocks throughout the formation are cemented by authigenic clinoptilolite, and by calcite, which replaces clinoptilolite, plagioclase, augite, and volcanic rock fragments.

Sedimentary structures are common in the lower half of the formation and include laminated crossbedding, flute casts, and groove casts.

All features indicate a general westward flow of paleocurrents. Fossils found within the formation suggest a bathyal, offshore environment of deposition.

### Itinerary

9:15 AM: Assemble in lobby of the University Tower Hotel and board chartered busses for trip to Bremerton.

10:00 AM: Leave for Bremerton aboard a "Jumboferry" of the Washington State Ferry System. Please note that complete food service, including coffee, rolls, etc. is available on the upper deck.

As we leave Seattle, Elliott Bay, Seattle's major marine cargo moorage, will be off the port side of the vessel, and Bainbridge Island will be visible in the distance.

As we leave the ferry terminal you may notice the cluster of large hotels and high-rise buildings a few blocks up the hill. This area is known as the "University Block", and is now the location of the Olympic Hotel (the GSA Headquarter's Hotel) and the Seattle Hilton along with several large banks. The area received its name in a most interesting way, beginning with the founding of the University of Washington in a single building on the site of the present Olympic Hotel in 1861. About the turn of the century the city fathers became concerned that the presence of the University on such a good business site was detrimental to the growth of the city of Seattle, so the campus was moved to a ranch on the shores of Lake Washington. However, the University retained title to the land. Recently, the "University Block" has become the prime site for building in downtown Seattle, as witnessed by the cluster of tall buildings. The relationship between downtown business and the University has become a profitable one for the University, as rental and lease income from the property now is about \$5 million a year. The University uses this income for capital construction.

10:30 AM: On our way into Bremerton we have to pass through Rich Passage, a very narrow passage that guards the harbor at Bremerton. Rocks exposed on either side of the passage are bedded sedimentary rocks of the Blakley Formation, and are the exposures we will visit on the second stop on our trip.

The nature of Rich Passage is what made Bremerton a prime choice as a strategic port for the Navy. The passage is over 80 feet deep at low water, and is subject to tremendous tidal currents. At one time it was guarded by an artillery station set up on the south end of Bainbridge Island, but only the concrete bunker and gun bases remain today.

11:00 AM: Arrive in Bremerton, Washington. On our way to the first stop we will pass the MISSOURI and several aircraft carriers. The MISSOURI is open for visiting from 10:00 AM until 4:00 PM every day. However, visitors are only allowed on the front deck, and in the War Room, as the remainder of the ship is kept sealed under very low humidity conditions.

11:10 AM: Arrive at the Pioneer Quarry, Gorst, Washington. The rock being excavated at the Pioneer Quarry is volcanic rock of the Crescent Formation. The quarry exposes several varieties of rocks characteristic of the Crescent, including breccias and an altered basalt locally known as "red rock". Zeolites are abundant in much of the quarry, and are especially common in the more vesicular portions of flows and in vugs in the breccias. AVOID ANY STEEP WALLS IN THE QUARRY. This is an active quarry being mined for decorative rock and road metal, so any of the steep walls must be considered very unstable.

12:00 PM: Box lunches will be served.

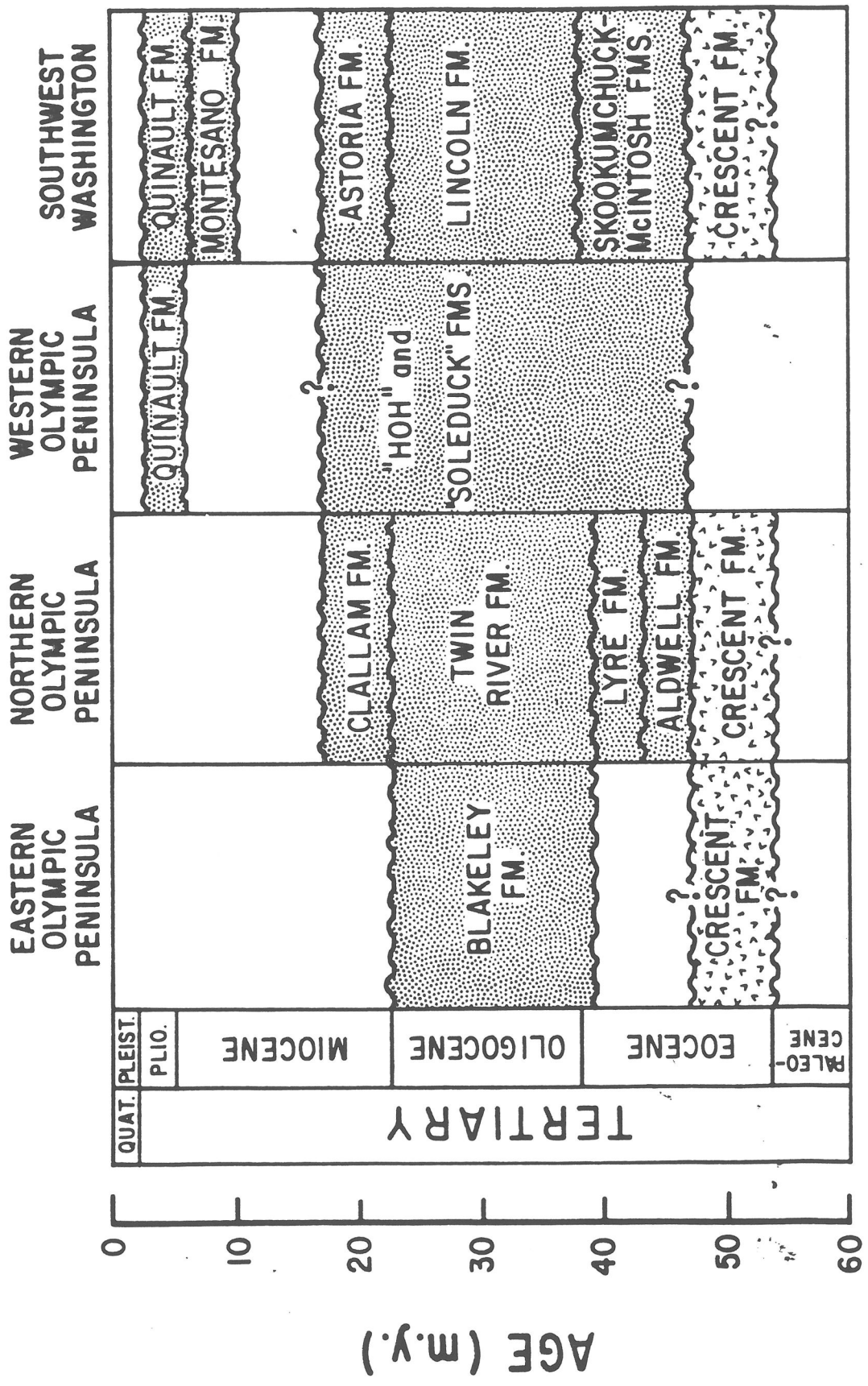


Diagram showing the stratigraphic relationships between the Blakeley and Crescent Formations, and other lithologic units on the Olympic Peninsula.

- 12:45 PM: Leave for Fort Ward and Bean's Point. Our route will take us through the rural countryside of the Kitsap Peninsula and Bainbridge Island. Along the way we will pass through Poulsbo, a small village with a strong Scandinavian heritage, and over the bridge at Agate Passage, which is the second possible entrance to the harbor at Bremerton. This area is undergoing a tremendous population increase associated with the development of the Trident submarine base at Bangor, opposite the Naval Torpedo Station at Keyport.
- 1:20 PM: Arrive at Bean's Point, Bainbridge Island. Rocks exposed on the beach are thin-bedded sandstones and massive siltstones of the Blakely Formation. These exposures were visible out the starboard side of the ferry on the trip to Bremerton. The section exposed between here and Restoration Point is about 3500 feet thick, and is a monotonous succession of fine-grained sandstone and siltstone. Calcite is present as a cement in some of the rocks, and these tend to be slightly more resistant to erosion. However, many rocks are cemented by clinoptilolite, which may constitute 90 percent of some siltstones. Sedimentary structures developed in the sandstones include flute casts, flame casts, load casts, cross-bedding, and graded bedding.
- The bunkers and gun pads from the original fort guarding Rich Passage are present on the south side of the road. This fort was the last of a whole series of gun emplacements erected at strategic sites along Puget Sound about 1900. Most of them have been abandoned, but the two which guard the entrance to Puget Sound near Port Townsend have been converted into state parks, and the guns have been restored.
- 2:00 PM: Leave for ferry terminal at Winslow. As we leave the beach, we will pass the site of old Port Blakely, which once was the major logging center of Puget Sound. Now the only thing that remains are the old pilings. The harbor is a favorite site for divers looking for old bottles thrown off the logging ships, etc.
- 2:45 PM: Arrive Winslow.
- 3:30 PM: Arrive at Seattle ferry terminal. Because all of the major hotels are reasonably close together downtown, the bus will return to the University Tower by way of the major downtown hotels. You may want to check out of the Tower before we leave on Sunday morning, and have your luggage placed aboard the bus, thus avoiding having to return to downtown Sunday evening.
- 4:30 PM: Arrive University Tower Hotel.





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