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Phytoliths from CRP-1

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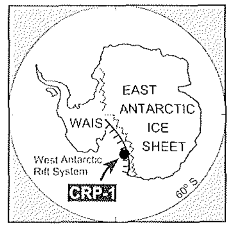
Abstract - This report documents the phytoliths (siliceous plant fossils) in 16 samples from the Cape Roberts Project core (CRP-1), including the first record of two phytolith forms from monocotyledons (Chionochloid (spool) and Elongate) in Antarctica. The phytoliths found are compared with those extracted from extant plants and other Antarctic sedimentary deposits. The phytolith record is also compared with the three floral assemblages indicated by terrestrial palynomorphs for the Miocene and Quaternary sections of the core.



INTRODUCTION

Phytoliths are silica plant microfossils which are produced in great numbers. They are produced when certain higher living plants deposit solid silica within and between the cells, from silica absorbed by the plants in a soluble form with the ground water. The shapes of the silicified bodies in many plants are highly distinctive and in many cases are identifiable to a species level. When a plant dies most of its phytoliths are released directly into the soil, creating an *in situ* record of vegetation.

Historically phytoliths have been described in the scientific literature since the early 19th Century (Struve, 1835); but it was not until the late 1960s and early 1970s that western soil scientists and botanists began using them in research work (Piperno, 1988). The potential of phytoliths for use in paleoenvironmental reconstruction was first recognised by Rovner (1971), who pointed out that phytolith analysis could provide paleobotanical information comparable to palynological data in many areas where pollen is absent. For example Wilding & Drees (1969) used phytoliths to describe the vegetational changes that had occurred on the great plains of North America during the Holocene. Another example where phytoliths were used was in the identification of buried paleosols (Dormarr & Lutwich, 1969).

In Antarctica to date there has been little research on phytoliths. Kondo et al. (1994) extracted and photographed a small number of phytoliths from CIROS-1 and CIROS-2 cores. The phytoliths recovered from the CIROS-1 core are contained within an upper Eocene sedimentary sequence (Wilson et al., 1997). The phytoliths recovered from the CIROS-2 core are contained within a Pliocene sedimentary sequence (Barrett et al., 1992). Bleakley (1996) found abundant phytoliths in Sirius Group diamicts. Carter (in press) extracted and described phytoliths from the Devonian to Triassic Beacon Supergroup sediments and from the Mount Feather Sirius Group Core (Carter, 1998).

In order to determine whether phytoliths were present in the CRP-1 core, 16 samples from fine-grained or organic-rich strata were processed for phytolith extraction (Tab. 1). The phytoliths were compared with microphotographs of phytoliths extracted from extant Antarctic, Sub Antarctic, New Zealand plants and other Antarctic sedimentary deposits (Plate 1), as well as published forms. The phytolith record is compared with the three floral assemblages indicated by terrestrial palynomorphs in the Miocene and Quaternary sections of the core (Cape Roberts Science Team, 1998). An unconformity at 43.55 mbsf separates the Miocene from the Quaternary section of the core.

PHYTOLITH EXTRACTION METHOD

The method of phytolith extraction described here is similar to methods described by Piperno (1988) and Hart (1988).

Ultra-clean laboratory practices were followed throughout all processing steps so as to avoid contamination. The organic component was removed by heating in 27% hydrogen peroxide. Following washing to remove any hydrogen peroxide, the residue was wet sieved at 250 µ and the coarser material discarded.

Ultrasonic treatment was used to break down the organic and clay complexes to release phytoliths. Clay-sized particles <5 µ were removed by settling and any remaining organic material was removed by digestion using "Schulzes Solution" (Traverse, 1988).

Finally the phytoliths (specific gravity about 2.3) were floated off from the other mineral silicates using a sodium polytungstate solution diluted to a specific gravity of 2.3, and the phytoliths recovered were mounted for visual examination.

RESULTS

Phytoliths were abundant and ranged from well preserved to poorly preserved in all samples. Phytoliths were assigned to one of the following morpho-groups

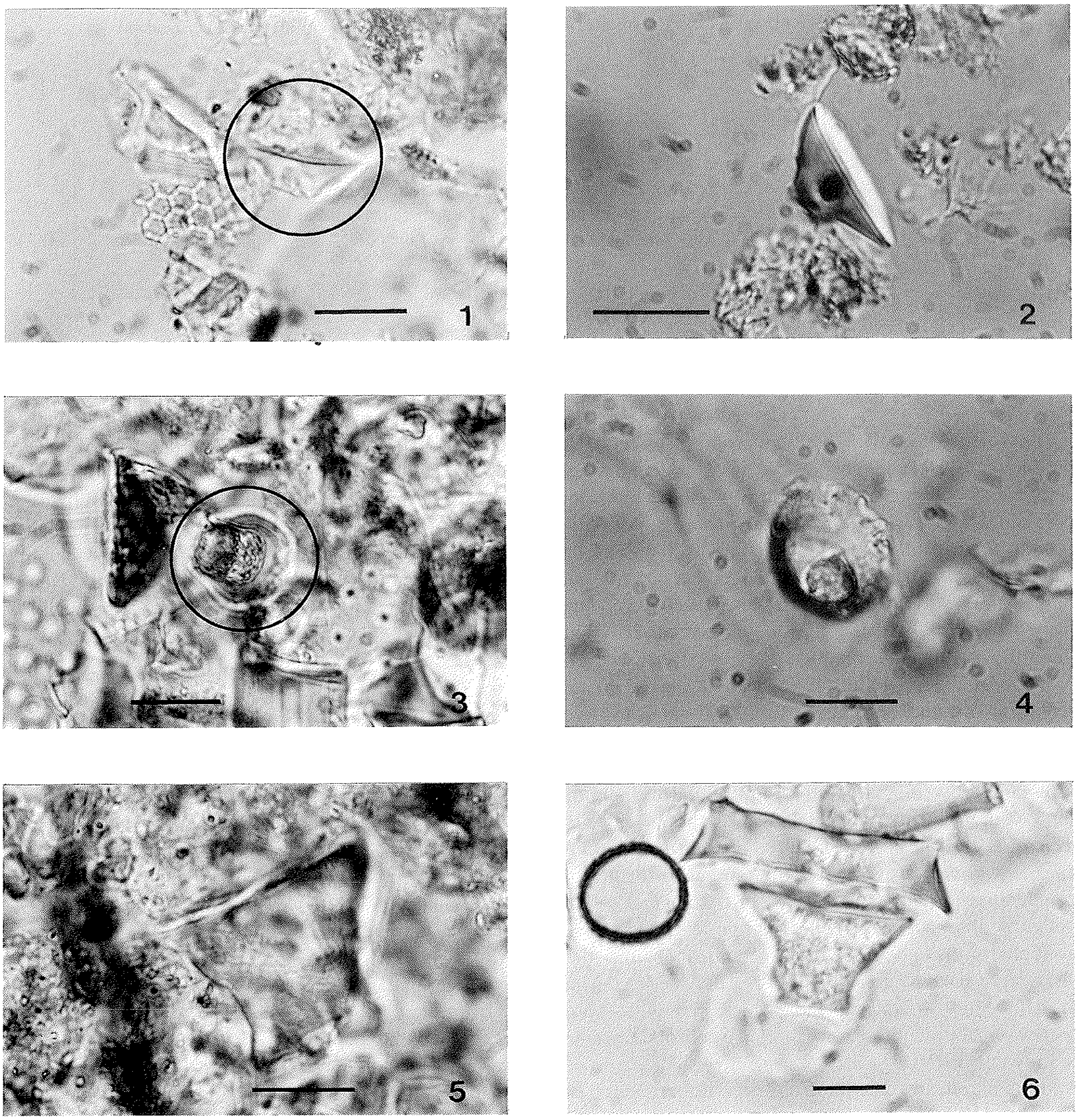


Plate 1 - Scale bar on all photographs = 10 µ. *1)* Chionochloid/Spool phytolith (Circled) from 123.85 mbsf. *2)* Chionochloid/Spool phytolith from extant *Deschampsia antarctica* Fallieres Coast, Antarctic Peninsula. *3)* Chionochloid/Spool phytolith (vertical view) (Circled) from 58.60 mbsf. *4)* Chionochloid/Spool phytolith (vertical view) from extant *Juncus Inconspicuus*, South Georgia. *5)* Chionochloid/Spool phytolith from 30.97 mbsf. *6)* Chionochloid/Spool phytolith, Bantra Loess, Southland, New Zealand.

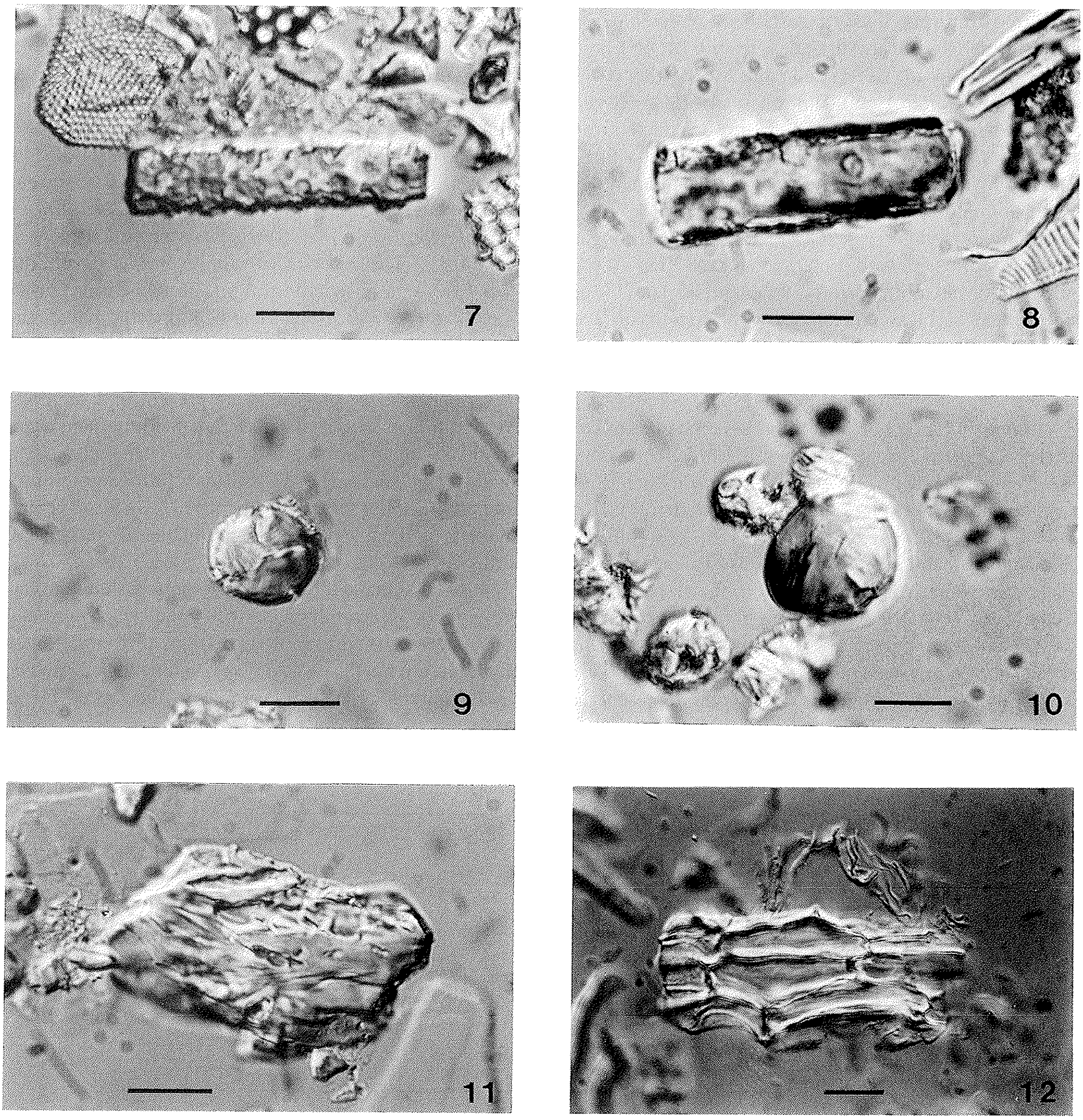


Plate 1 - Continued. *7)* Elongate phytolith from Sample 123.85 mbsf. *8)* Elongate phytolith from extant *Juncus inconspicuus* , South Georgia. *9)* Spherical phytolith from 123.85 mbsf. *10)* Spherical phytolith from extant *Nothofagus menziesii*. New Zealand. *11)* Etched polyhedral phytolith from 123.85 mbsf. *12)* Etched polyhedral phytolith from *Cyathea medullaris* New Zealand.

based on Kondo et al. (1994). Abundances were gauged by scanning the whole slide to make an approximation.

Spherical phytoliths are present in 14 samples (Tab. 1, Plate 1.9). Preservation is good, and specimens are 5 to 19 μ in size. Spherical phytoliths are probably the most distinctive forms from trees and shrubs. They develop as inward projections of the cell wall. Similar forms were extracted from a previously undescribed core sample from beneath the Ross Sea, Antarctica, from CIROS-1 & -2 cores (Kondo et al., 1994) and from Mt. Feather Sirius Group Core (Carter, 1998). The Spherical forms have very similar shape and surface texture to those extracted from extant *Nothofagus menziesii* (Plate 1.10). Similar forms are also found in a number of Proteaceae and other New Zealand tree species.

Elongate phytoliths are present in 5 samples. Elongate phytolith forms are well preserved and are 30 to 70 μ in size. These phytoliths are flat rectangular plates, some with pitted surfaces and others with smooth surfaces (Plate 1.7). The form found at 123.85 mbsf is very similar to the elongate form extracted from an extant rush, *Juncus inconspicuus,* from South Georgia (Plate 1.8).

Chionochloid/Spool phytoliths have been extracted from 3 samples (Plate 1.1, 3 & 5). Preservation is good, however only one specimen was found on each slide. Chionochloid/Spool phytoliths are distinctive forms from cold climate grasses. Similar forms to that found at 30.97 mbsf are found preserved in New Zealand loess (see Plate 1.6) which was extracted from the Bantra Loess, Southland, New Zealand. Similar forms to that found 56.60 mbsf are found in present day South Georgia extant species *Juncus inconspicuus* (Plate 1.4). The form found at 123.85 mbsf is very similar to those found in present day Antarctic Peninsula species *Deschampsia antarctica* (Plate 1.2).

Irregular multifaceted phytoliths are present in 13 samples. Preservation is good, and they are 20 to 60 μ in size. Irregular Multifaceted forms are 3 dimensional, have an irregular outline and have multiple facets or folds. Similar forms were extracted from a previously undescribed core sample from beneath the Ross Sea, Antarctica. Irregular Multifaceted phytoliths were extracted from extant *Guatteria dumetorum* (Annonaceae family in the angiosperm order Magnoliales, which first appeared in the Cretaceous (Stewart & Rothwell, 1993)) by Piperno (1988).

Spherical multifaceted phytoliths are present in 11 samples. Preservation is good, and specimens are about 20 μ in size. Spherical Multifaceted are spherical with multiple facets. Similar forms were extracted from a previously undescribed core sample from beneath the Ross Sea, Antarctica and from Mt. Feather Sirius Group Core (Carter, 1998). Spherical Multifaceted phytoliths were extracted from *Unonopsis pittieri* (Annonaceae family) by Piperno (1988).

Irregular cubic phytoliths are present in 5 samples. Preservation is good, and they are 8 to 16 μ in size. Irregular Cubic forms are 3 dimensional and have a roughly cubic shape. The source of these forms are presently unknown. Similar forms were extracted from Sirius Group diamicts by Bleakley (1996), and from the Mount Feather Sirius Group Core (Carter, 1998).

Jigsaw (anticlinal) phytoliths are present in 8 samples. Preservation is generally good with good clean edges and some pitting, and specimens are 20 to 57 μ in size. Jigsaw phytoliths are flat plates with wavy, undulating edges. The Jigsaw phytoliths are very similar to the jigsaw forms

Tab. 1 - Abundances of phytoliths by sample.

CRP 1 Samples	Marine Microfossils			Phytoliths								
Depth (m)	Diatoms	Sponge Spicules	Silicoflagellates	Spherical (*Nothofagus*)	Elongate	Chionochloid/Spool	Irregular Multifaceted	Spherical Multifaceted	Irregular Cubic	Jigsaw/Anticlinal *	Polyhedral *	Etched Polyhedral *
19,44	R			R			A			C	R	R
30,97	C-R	C-R	R	R		R						C
45,03	C	C		R						R	C	C-R
52,73	C	C	C-R	R	R		C			R	C	
58,6	C	C	C-R	R				R		R	C	C
66,27	C	C-R	C-R	R			C-R	R		R	C	
75,38	A	C-R	C-R				C-R	R			C-R	C-R
82,62	A	C-R	C-R	R	R		C-R	R			C-R	C-R
87,53	A	C-R	C-R	R			C-R		R		R	
96,14	A	C-R		R	R		C-R	R		R		
109,14	C	C-R	C-R	R			C-R	R		R	C-R	C-R
116,2	C	C-R	C-R			R	C-R	R			C-R	
123,85	C-R	R	R	R	R	R	C	R	R	R	C-R	C-R
129,42	R	R	R	R			A	R	R		C-R	
135,01	R	R	R	R	R		A	R	R		C-R	
145,82	C-R	R	R	R			A	R	R			R

Note: A = Abundant (>50 %); C = Common (<50 % >25%); C - R = Common to Rare (<25% >5%); R = Rare (<5%); * Phytoliths found in Beacon Supergroup Sediments.

extracted from late Devonian, Permian and Triassic Beacon Supergroup sediments (Carter, 1998, in press). These type of phytoliths are common to deciduous trees, herbaceous dicots, and ferns (Piperno, 1988; Bozarth, 1992; Kondo et al., 1994).

Polyhedral phytoliths are present in 13 samples. They have a plate-like appearance of 4 to 8 approximately straight sides, range in size from 25 and 100 μ and the majority have pitted surfaces. The polyhedral phytoliths are very similar to the polyhedral forms extracted from Beacon Supergroup sediments (Carter, in press) and from Mt. Feather Sirius Group Core (Carter, 1998). Polyhedral epidermal forms have been extracted from extant deciduous trees and are described by Bozarth (1992) and Wang & Hill (1995). Polyhedral phytoliths have recently been extracted from extant Southern Hemisphere *Nothofagus* and *Dacrydium* species. However, it should be noted that polyhedral phytoliths are also produced by many herbaceous dicots (Bozarth, 1992).

Etched polyhedral phytoliths are present in 9 samples. Preservation is generally good with good clean edges, and specimens are 20 to 80 μ in size (Plate 1.11). Etched forms consist of a flat plate, with a hollowed top surface which leaves ridges that give an etched appearance. Similar forms were extracted from a previously undescribed core sample from beneath the Ross Sea, Antarctica, from Beacon Supergroup sediments (Carter, in press) and from Mt. Feather Sirius Group Core (Carter, 1998). Phytoliths of a somewhat similar appearance have been extracted from extant tree fern species *Cyathea medularis* (Plate 1.12).

DISCUSSION

This report documents the phytoliths (siliceous plant fossils) in 16 samples from the Cape Roberts Project core (CRP-1). The phytolith record is compatible with that from terrestrial palynomorphs for the Miocene and Quaternary sections of the core (Cape Roberts Science Team, 1998). The palynomorph record suggests three assemblages, which are compared with the phytolith record below.

a) A large reworked group of miospores which are probably derived from the Beacon Supergroup sediments. The phytolith forms Jigsaw/Anticlinal, Polyhedral and Etched Polyhedral are similarly reworked as they also occur in the same sediments (Carter, in press).
b) A *Nothofagus*-dominated woodland with a variety of woody plants (including Proteaceae and Podocarpaceae). Spherical phytoliths are generally indicative of trees and shrubs, however, it should be noted that the form in Plate 1.9 from 123.85 mbsf is more specific. A comparison of it and the phytolith in Plate 1.10 from extant *Nothofagus menziesii* demonstrates a very close relationship. It is possible that Spherical phytoliths are derived from this type of mixed warm-climate woodland. Irregular Multifaceted phytoliths were the most abundant form with high percentages at 19.44 mbsf and between 145.82 and 129.45 mbsf. The presence of this Magnoliales form (indicative of tropical to warm temperate trees and shrubs) also adds credence to the mixed, warm-climate woodland of Cape Roberts Science Team (1998). However, *Nothofagus* scrub is found growing in sub-antarctic conditions at the edges of South American glaciers (Veblan et al., 1996).
c) A herb tundra formation dominated by mosses with a low diversity of vascular plants. The phytoliths that probably represent this vegetation are the few Chionochloid (spool) and Elongate forms. These phytoliths have also been extracted from extant monocotyledons which survive in the depauperate Antarctic and sub Antarctic tundra vegetation of the Antarctic Peninsula and South Georgia. The close relationship between the monocotyledon phytoliths from CRP-1 and those extracted from extant monocotyledon vegetation from South Georgia and the Antarctic Peninsula are shown in plate 1.1 to 1.8. This is the first record of these types of phytolith from Antarctica.

In conclusion this phytolith record demonstrates a compatibility with the palynomorph record. Palynomorphs are currently more certainly linked to particular plants, and their biostratigraphy is better known than phytoliths. However, they are more likely to be blown in from distant sources. Phytoliths have an advantage in that they are continued to be produced by plants that stop flowering because of stress following a cooling change of climate. A more complete and better understood record of phytoliths would greatly add to understanding of past Antarctic floras and climate.

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