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PRELIMINARY STUDY OF MICROTEKTITES
FIRST DISCOVERED IN THE CENTRAL
PACIFIC BY CHINA

P. Hanchang, Y. Shong, M. Xi, S Shijie

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16. Abstract A description is given of the preliminary study of microtektites first discovered in the Central Pacific by China. Electron probe analysis was used to determine the chemical composition. An X-ray energy spectrum analysis was made, and the surface microstructure was investigated. The found microtektites appear to be younger than the microtektites reported in the Asia Australia Strewn Field.			
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P. Hanchang, Y. Shong, M. Xi, S Shijie

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Peng Hanchang (The First Institute of Oceanography, China Bureau of Oceanography), Yu Shong and Miu Xi (Institute of Petroleum Exploration and Development), and Shuang Shijie (Institute of Geology, Ministry of Metallurgical Industry).

INTRODUCTION

In 1979, during its global atmospheric survey, the Chinese ocean survey ship "Xiangyanghong 09" collected many specimens of surface and cylindrical sediments from the western Central Pacific ($10^{\circ}\text{S}-5^{\circ}\text{N}$, $160^{\circ}-170^{\circ}\text{E}$). When we conducted mineralogical studies on these specimens, deepsea cosmic dust was discovered for the first time. A preliminary investigation was performed. Afterward, a study was carried out on a microglassy sphere which was named "glassy silicate cosmic dust" (i.e., microtektite). It was found that: (1) the "Central Pacific Microtektite" is a typical microtektite from the viewpoints of chemical composition as well as microstructure characteristics. It has a significant meaning in the areas of meteorite, space chemistry, and astronautics; and (2) the landing area of the microtektite discovered by China is outside the four "strewn fields" for tektite^[2] determined by the scholars. They are similar to the tektites in the Asian-Australian strewn field. This discovery has already received the praise from relevant scholars in the world. It is valuable to the further determination of the strewn field range and origin of tektites.

I. General Situation of Ocean Area Surveyed

The sediment surveying area was divided into two zones: Zone I ($4^{\circ}\text{S}-10^{\circ}\text{S}$, $170^{\circ}-173^{\circ}\text{E}$) was located south of Ocean and Gilbert Islands, west of Tokelan Islands and the Melanisia Basin, and bordering Weitiatz trench in the south. The seafloor inclines from northwest toward the southeast. The water depth at the sampling points was usually 2,000-4,500 m. The maximum depth was 5,443 m.

Zone II ($4^{\circ}\text{S} - 5^{\circ}\text{N}$, $160^{\circ}-165^{\circ}\text{E}$) was located south of Kusaie

*Tran. Note: Numbers in margin indicate foreign pagination.

Island, west of Naura Island, and east of Kapingamarangi Rise. The seafloor inclines from the southwest towards the northeast. The water depth at the sampling points was usually around 2,000-4,500 m. The maximum depth was 4,761 m.

In the two regions we had collected a total of 10 surface samples and 4 cylindrical specimens. Their specific positions, water depths, and sediment characteristics are listed in Table 1.

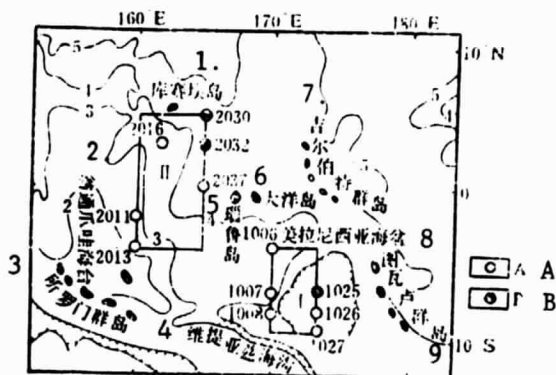


Figure 1. Positions of Surveyed Ocean Areas:

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- A. other sampling point;
- B. microtektite discovered by China.

- Key:
- 1. Kusaie Island
 - 2. Kapingamarangi Rise
 - 3. Solomon Islands
 - 4. Weitiatz Trench
 - 5. Nauru Island
 - 6. Ocean Island
 - 7. Gilbert Islands
 - 8. Meilanisia Basin
 - 9. Tokelau Islands

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OF POOR QUALITY

1 海 区	2 站 号	3 站 位		6 水深 (米)	7 沉积物岩性	8 备 注
		4 纬 度	5 经 度			
I	1006	4°00'S	169°58'E	3.475	钙质软泥 9	表 层 10
	1007	6°01'S	169°57'E	3.437	钙质软泥 11	表层和柱样(4.05米) 12
	1008	7°59'S	170°00'E	4.934	硅钙质软泥 13	表 层 14
	1025*	6°00'S	173°15'E	5.443	红 粘 土 15	表 层 16
	1026	8°01'S	173°18'E	5.357	红 粘 土 17	表层和柱样(4.19米) 18
	1027	9°56'S	173°19'E	5.061	红 粘 土 19	表 层 20
I	2016	2°59'N	161°43'E	3.769	钙质软泥 21	表 层 22
	2011	2°59'S	159°59'E	4.214	钙质软泥 23	柱 样(4.14米) 24
	2013	3°59'S	160°00'E	2.178	钙质软泥 25	表 层 26
	2030*	5°00'N	165°00'E	4.761	硅钙质软泥 27	表 层 28
	2032*	2°59'N	164°55'E	4.214	硅质软泥 29	柱 样(4.25米) 30
	2037	0°00'	165°00'E	4.408	钙质软泥 31	表 层 32

33 *表示在该站发现了微玻璃陨石.

Table 1. Positions, Water Depths, and Sediment Rock Characteristics of Sampling Stations.

- Key:
1. Ocean Area
 2. Station number
 3. Station position
 4. latitude
 5. longitude
 6. water depth (m)
 7. sediment rock characteristics
 8. remarks
 9. calcium mud
 10. surface layer
 11. calcium mud
 12. surface layer and cylindrical specimen (4.05 m)
 13. silicon and calcium mud
 14. surface layer
 15. red clay
 16. surface layer
 17. red clay
 18. surface layer and cylindrical specimen (4.19 m)
 19. red clay
 20. surface layer
 21. calcium mud
 22. surface layer

23. calcium mud
24. cylindrical specimen (4.14 m)
25. calcium mud
26. surface layer
27. silicon and calcium mud
28. surface layer
29. silicon mud
30. cylindrical specimen (4.25 m)
31. calcium mud
32. surface layer
33. *denotes the discovery of microtektite at the station

From the table one can see that calcium mud and silicon-calcium mud are widely distributed in the surveyed area. They were weakly sticky gray and beige colored soft putty. The sediment at over 5,000 m depth in the Melanisia Basin was red clay. The cylindrical specimens obtained in various stations were light brown silicon containing soft putty.

These sediments, whose characteristics were different, contained a large amount of biological remains (foraminifer, shark teeth, etc.), volcanic lapillus, and manganese nodule. Furthermore, cosmic dust and microtektites were found.

II. Landing Points of Newly Discovered Microtektites

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After over 100 years of searching and collecting, scientists found that the tektites in the world are concentrated in four strewn fields (Figure 2), i.e., the North America strewn field (from Southern United States, through the Caribbean Sea, to Venezuela, in which the age of the tektites is approximately 32-34 million years), Czechoslovakia Strewn Field (located in Bohemia and Moravia in southern Czechoslovakia, in which the age is approximately 15 million years), Ivory Coast Strewn Field (located along the coast of Ivory Coast and Ghana in which the age is approximately 1 million years), and Asia-Australia Strewn Field (located in the ocean south of Japan, through various countries south and southeast of China, eastern Indian Ocean, to Australia. With the exception of the 3-4 million year lunar tektite in Australia, the other ones were found to be around 700 thousand years in this region). Scientists believed that the tektites in the same strewn field were the product of the same tektite event. [3]

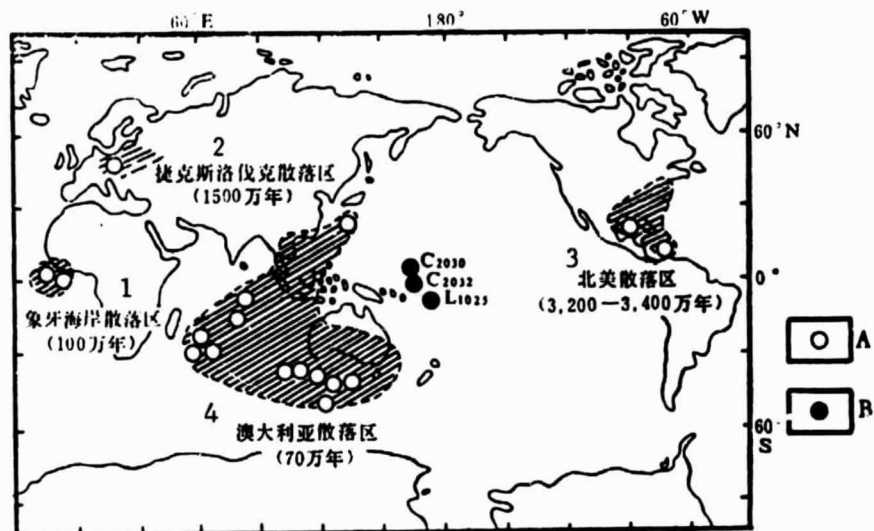


Figure 2. Strewn Fields of Tektites (John A. O'Keefe, 1978):

- A. landing points of tektites;
- B. landing points of microtektites discovered by China.

- Key:
- 1. Ivory Coast Strewn Field (1 million years)
 - 2. Czechoslovakia Strewn Field (1.5 million years)
 - 3. North America Strewn Field (32-34 million years)
 - 4. Australia Strewn Field (700 thousand years)

We found over 40 microtektites among the surface layer and cylindrical specimens collected at Stations 2030, 2032, and 1025. These discovery points are out of the aforementioned Asia-Australia Strewn Field (Figure 2). However, from the viewpoint of the chemical composition and microstructure of the microtektites, they may still belong to the microtektites in this region. Some foreign scientists also presented the same conclusion (private communications). Thus, the area of Asia-Australia Strewn Field is further expanded.

III. Microscopic Characteristics

The various soft mud samples were rinsed with water.

In the remaining sands, if there were too many biological shells, a 5% dilute hydrochloric acid was added to dissolve them. They were rinsed with water again and dried to be placed under the microscope for observation. When the crushed minerals were being /197 identified, cosmic dusts were found in the specimens from each station. They were mostly black or brown round or oval particles. Microtektites were only discovered in specimens collected in a few stations.

Under a regular microscope at fifty to sixty power, microtektites were transparent or light yellowish green small glassy balls. The former had a smooth surface, while the latter were uneven with small crests. A few microtektites were dark green balls. Their diameter is usually around 0.2 mm. The larger ones could be 0.34 mm (Plate I, Photograph 1). Under a polarized microscope, the index of refraction of the Central Pacific Microtektite was determined to be 1.48-1.50 using an oil immersion method. Under a perpendicular polarizer, light was totally polarized.

IV. Chemical Composition

(1) Electron Probe Analysis

An electron probe was used to measure the chemical composition of various microtektites. Table 2 lists the results of six specimens. A comparison was also made with respect to the measured results of similar specimens in the foreign literature.

1 样号	2 氧化物	SiO ₂	TiO ₂	Al ₂ O ₃	FeO	MgO	CaO	Na ₂ O	K ₂ O	MnO	3 备注
No.1		68.33	0.90	16.10	6.24	2.66	2.57	0.68	2.29	0.10	图版 I, 照片3 ⁴
No.2		66.34	0.91	16.19	5.25	2.94	2.65	0.51	2.96	0.10	图版 I, 照片2 ⁵
No.3		62.72	0.11	18.48	3.52	1.55	2.75	1.55	8.25	0.09	
#8(4)		67.90	0.80	15.20	5.70	2.70	2.90	1.70	3.20	0.10	
No.4		42.79	0.12	2.25	18.17	34.69	1.84	0.00	0.03	0.45	图版 I, 照片5 ⁶
No.5		41.86	0.08	0.04	0.02	56.97	0.07	0.00	0.01	0.07	图3(3)、 图4(4) ⁷
V27-259(8)		41.80	0.15	6.00	4.20	35.60	5.60	2.60	0.00	—	
No.6		98.45	0.00	0.05	0.18	0.04	0.01	0.04	0.01	0.00	图版 I, 照片3、 图3(3)、4(4) ⁸
#18(4)		98.10	—	0.10	0.10	—	0.01	0.02	0.04	0.01	
9 海底火山玻璃*		44.70	0.00	15.30	0.00	2.20	1.90	4.50	4.00	2.90	

10 *站位: 13°28'S, 149°30'W; 水深 4.300 米 (J. Murry & A.F. Renard, 1891) .

11 "—" 表示未测.

Table 2. Results of Electron Probe Analysis of Central Pacific Microtektite and Comparison

- Key: 1. sample number
 2. oxide
 3. remarks
 4. Plate I, Photograph 3
 5. Plate I, Photograph 2
 6. Plate I, Photograph 5
 7. Figure 3(3), 4(4)
 8. Plate II, Photograph 3, Figure 3(3), 4(4)
 9. seafloor volcanic glass*
 10. *station position, 13°28'S, 149°30'W, water depth 4300 m (J. Murry & A.F. Renard, 1981)
 11. "—" denotes not measured

From the table one can see that the chemical compositions of different microtektite particles are not identical. But, the SiO₂ content is usually very high. Some of them reached as high as 98% and none are lower than 40%. This is an important chemical characteristic of the ordinary tektite. A few microtektites showed a relatively higher MgO content. These characteristics are not only apparent from the electron probe analysis listed in the table, but also can clearly be reflected from the

x-ray energy dispersion spectrum (Figure 3) and electron density pattern (Figure 4) shown later.

The chemical composition of the Central Pacific microtektite is very similar to that of the microtektite (such as #8^[4]) found in the Asia-Australia Strewn Field.

It should be especially pointed out that the chemical composition of the Central Pacific microtektite is different from that of the seafloor volcanic glass (which had been proven by scientists long ago). First, from the table one can see that a volcanic glass does not contain TiO_2 and FeO , and its Na_2O and MnO contents far exceed those in a microtektite. Secondly, their /198 morphology, surface characteristics, and other physical properties are also drastically different under the microscope.

In addition, in the "remarks" column in Table 2, the corresponding plate numbers and photograph numbers of the SEM pictures of the probe analyzed samples (first analyzed by scanning electron and their electron probe) and the photographs in Figures 3 and 4 are listed for comparison.

(II) X-ray Energy Spectrum Analysis

Before carrying out an electron probe analysis, the x-ray energy spectrum was measured by using the x-ray dispersion spectrometer, which came as a part of the scanning electron microscope. In the analysis, a lithium-silicon [Si(Li)] semiconductor detector was used as the probe. Its resolution with respect to the 5,900 eV (electron volt) $MnK\alpha$ beam was 152 eV. It was capable of analyzing elements from Na^{11} - U^{92} . The high voltage of the electron gun was 20 kV (kilovolts). The x-ray count was 1,800-1,900/sec and the pre-set count was 20,000. The spectrum was counted by peak height and integral (automatically subtracting the background). The readouts and photographed records of the spectral lines were compared.

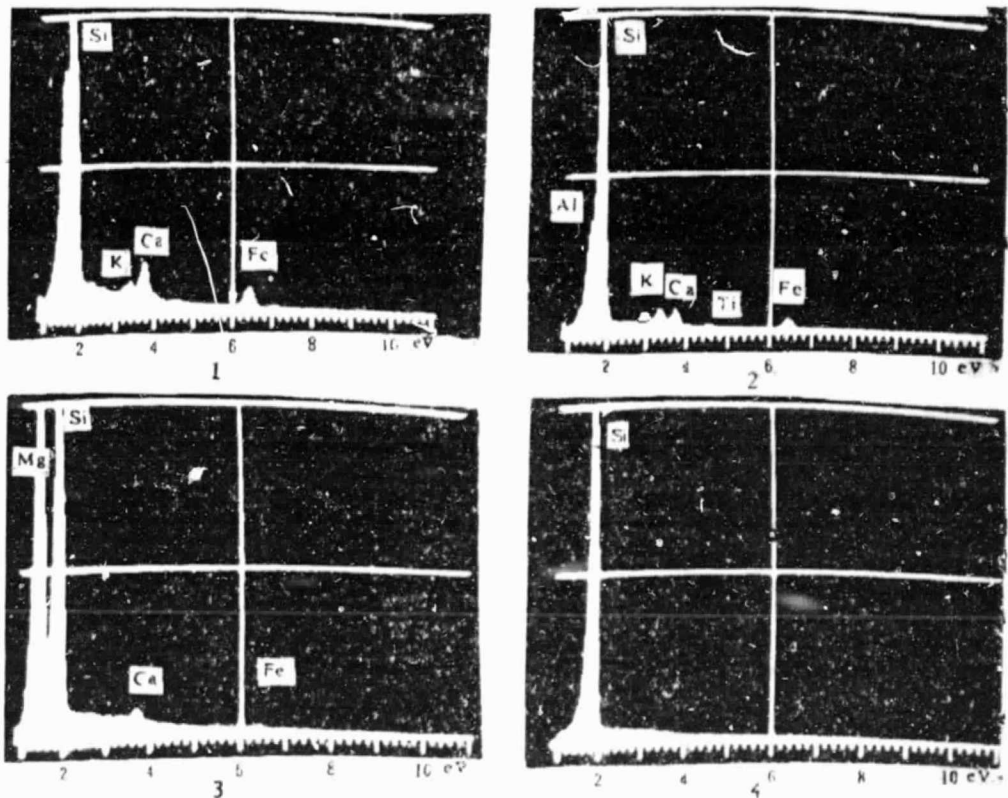


Figure 3. Part of X-ray Dispersion Spectrum of Central Pacific Microtektite

The spectra and surface distribution diagrams of a part of the specimens obtained by x-ray analysis were shown in Figures 3 and 4, respectively. From the spectra, the Si contents were very high in all the specimens. The Si content in an individual sample (No. 6) reached as high as over 98%, similar to the silicon balls in the lunar soil. Another sample (No. 5) had a high Mg content [(3)]. The peak for Al was mostly buried by that of Si. From the surface distribution patterns, a high Si content was also shown in these patterns [Figures 4(1,2,3)]. The Mg content in an individual specimen (No. 5) was also very high (4).

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The above x-ray energy spectrum results are in agreement with those of electro. probe analysis.

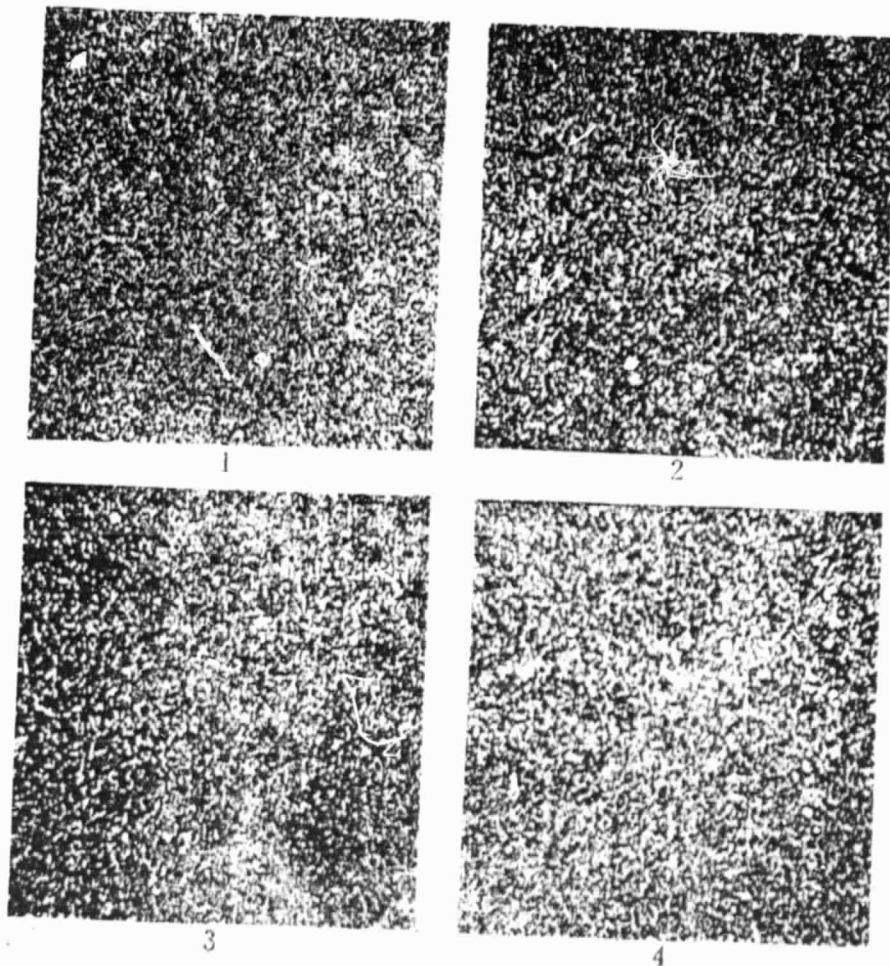


Figure 4. Surface Distribution of X-ray Energy Dispersion Analysis of Central Pacific Microtektite

(1,2,3 are the SiK α surface distribution of various particles, and 4 is the MgK α surface distribution of specimen No. 5)

V. Surface Microstructure

In order to further identify the Central Pacific Microtektite and to explore its formation mechanism, the morphology and surface microstructure were observed using a scanning electron microscope and the secondary electron images were photographed at various magnifications.

Most of the Central Pacific microtektites are relatively smooth spheres or ellipsoids. A few of them are spheres with a rough surface (this type also exists in research materials abroad). On a relatively smooth spherical surface, circular craters and spots of various sizes are usually densely distributed on a certain side of the sphere. On the opposite side, they are relatively dilute. Some of the dents overlap each other. Or, small dents are located in a large crater (Plate I, Photograph 4). Some of the craters formed concentric circles with a bulging center, taking the shape of a "bamboo hat" (Plate I, Photographs 5 and 6). Some of the Central Pacific Microtektite particles were inserted with mineral envelopes, which were usually surrounded by cracks (Plate I, Photograph 5; Plate II, Photographs 1,2). Results of probe analysis showed that the major chemical composition of the envelope was SiO_2 (41%), Mg (34%), and FeO (23%). The contents of other components are very low. In addition, the surface of Central Pacific Microtektite has characteristics such a wavy shape (Plate I, Photograph 2), nipple shale (Plate I, Photograph 3) and fractured surface of a shell (Plate II, Photograph 4). /200

To facilitate the comparison between the Central Pacific microtektite collected by China and the relevant foreign literature, two scanning electron micrographs (Plate II, Photographs 5,6)^[2] of seafloor microtektites collected by American Scientists (in the Asia Australia Strewn Field) are also included, in addition to the information listed in earlier chapters. One can see that they are very similar in terms of morphology and surface microstructure.

VI. Discussion

Although a detailed description was given in each section to the summary in the introduction, yet certain problems still require to be discussed in order to obtain more satisfactory conclusions in future detailed studies.

1. From the chemical composition and microstructure of the Central Pacific microtektites, they are typical microtektites, basically in agreement with foreign studies. Microtektite is clearly different from seafloor volcanic glass. The former is a solid glassy particle which does not contain any bubble. In addition to a higher SiO_2 content, it also contains oxides such as Al_2O_3 and FeO , and a large number of minute elements^[7]. The latter is mostly glass fibers contaminated by volcanic dust or round glass fragments with bubble wall. Although their composition also contains various oxides, however, there is no TiO_2 and FeO . Moreover, the contents of Na_2O and MnO are usually higher than that of microtektite. Furthermore, a microtektite surface is covered with dents and spots from surface microstructure. The volcanic glass fragment, however, does not have such structural characteristics.

2. The landing points of the Central Pacific Microtektites first discovered by China were outside the four tektite strewn fields identified by the scientists. This is valuable in the aspect of further identifying the strewn range of tektites. Although, based on the geographic location, chemical composition, and surface microstructure characteristics of the Central Pacific microtektites, we temporarily categorize them in the domain of the Asia-Australia Strewn Field, however, they are younger than other microtektites (approximately 700 thousand years) strewn in the region according to the era of tektite sediment (which is 410 thousand years at the earliest based on ancient geomagnetic data). Therefore, the concept that it belongs to the "Strewn Field" of tektites as well as the idea and division of such regions must be further studied.

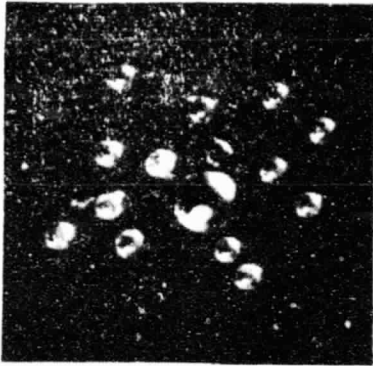
3. With regard to the cause and mechanism of the formation of dents and spots on the microtektite surface, some scientists

believed that it was the result of erosion by underground water (in the kernel of the rock in the ancient geological era) and seawater^[2]. We believe that it might be caused by the air flow. This requires more detailed studies.

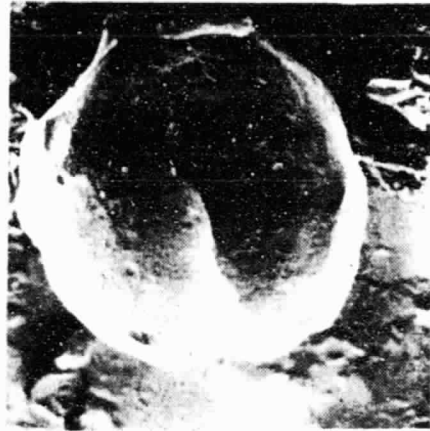
The study on microtektite was a continuation and extension of our study on deepsea cosmic dust. During this period, we received the guidance and assistance from Chairman Liu Minghou and American scientists J.A. O'Keefe and B.P. Glass. The authors wish to express their deep gratitude.

Plate I

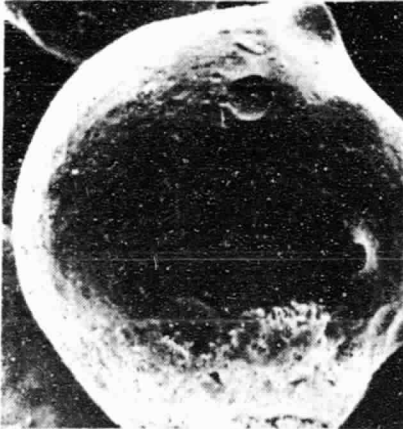
(Plate) I



1



2



3



4



5



6

Plate II

(Plate) II



1



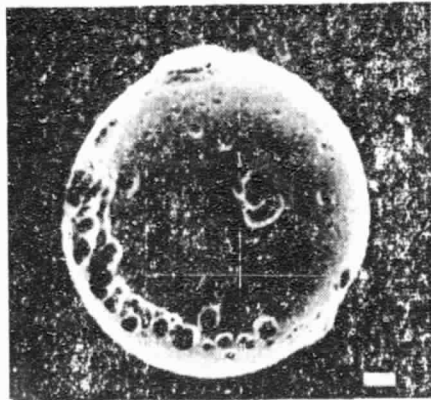
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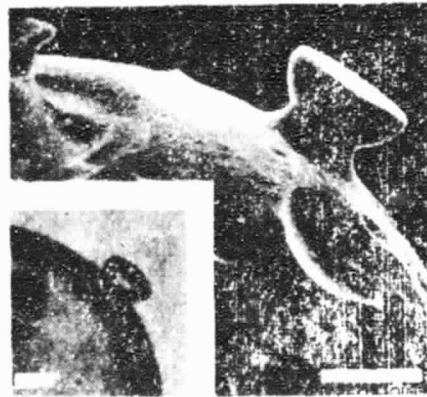
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