

Tektites in Thai Prehistory

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INTRODUCTION

IT IS no longer necessary to begin a paper in any way related to tektites with a lengthy and detailed discourse on the nature of tektites themselves. Since the Viennese scholar Franz Suess invented the name at the turn of the century and wrote the first comprehensive work on tektites (Suess 1900), they have become the object of serious scientific investigation, and the literature about them has grown, especially during the last twenty years or so, to more than a thousand titles (Barnes and Barnes 1973: ix).

Yet a very brief description of tektites may be useful here. Tektites are small, naturally formed (molten rock) glassy objects found in four distinct regions (strewn-fields) of the globe: North America, Czechoslovakia, the Ivory Coast (Africa), and the vast area including Southeast Asia and Australia. It is generally thought that these falls corresponded to four (or more) cosmic events which occurred about 33–35 million years ago, 14–15 million years ago, 1.3 million years ago, and 700,000 years ago respectively. What exactly these events were is still a hotly debated issue. As Gentner says (1964: 90), tongue in cheek, scholars who deal with tektites can still be divided into the four “sects” established by Chladni as early as 1819 of those dealing with the origin of meteorites: Cosmists, Lunarists, Atmospherists, and Tellurists. In other words, it is not yet agreed upon whether tektites are of terrestrial, lunar, or cosmic origin, and whether they are the result of the impact of meteorites, asteroids, comets, or of volcanic eruptions on earth or on the moon.

Be this as it may, it is not with the origin of tektites that we are concerned here, but with what happened to them once they were discovered by man. The main purpose of this paper, apart from reporting a newly discovered tektite field on the northwestern rim of the Australasian strewn-field, is to investigate the use of tektites in the past and present in what is now Thailand, an area of Southeast Asia which was not mentioned in Beyer’s fundamental work “The Relation of Tektites

to Archaeology" (1956) presented at the Fourth Far-Eastern Prehistory Congress in Manila. The present paper can thus be looked upon as a continuation of, or supplement to, that of Beyer.

THE AUSTRALASIAN STREWN-FIELD

This strewn-field, which includes the northeastern part of Thailand, is the largest of all tektite strewn-fields. Von Koenigswald divides it into three zones: a northern zone comprising that part of southern China where tektites occur, the Indochinese and Malay peninsulas, Billiton, and all of Borneo and the Philippines except their southernmost parts; a southern zone composed of Australia; and a central zone comprising everything in between, that is, the whole of Indonesia except Sumatra and the central part of Borneo. The difference in the most common forms of tektites in each of these areas—that is, "primary forms" (spheres or "dumbbells") in the northern, "secondary forms" (ablated spheres or "buttons") in the southern, and transitional forms in the central zone—can best be explained, he argues, by assuming that a large cloud of tektites approached earth from outer space and caused this gradation. Those in the northern zone would have thus come down almost vertically, "showing no ablation. But gradually to the south the angle of entry into the atmosphere would be lower and lower, reaching about 10° in Australia. Because of it the tektite would travel much longer through the air with the result that ablation would increase from north to south and this is indeed what we observe" (von Koenigswald 1967: 107–108).

The Australasian tektite strewn-field is not only the most extensive, but also by far the richest, especially in the northern zone. The total number of tektites fallen here will of course never be known, but figures like "40,000 tektites from Indochina examined" (Nininger and Huss 1967), "more than 10,000 specimens collected from an area between five and six square miles at Pugad Babuy Site, Philippines" (Beyer 1956: 389), or "more than a million tektites inspected in this strewn-field" (Chapman 1971: 6310) give an idea of the density of tektites in this area. That means that in some places at least, prehistoric man had an appreciable amount of this glassy raw material at his disposal.

A series of 18 tektites from different parts of this strewn-field (the Indochinese peninsula, Billiton, Java, Borneo, the Philippines, and central, western, and southern Australia) was dated by the potassium-argon method to roughly 700,000 years ago (Gentner 1964), an age which was later confirmed by dates obtained by using the fission track dating method (Gentner, Storzer, and Wagner 1969). However, as some Australites have been dated by other methods to vastly different ages, ranging from less than 5000 years ago (Baker 1960, 1962), over "Late Pleistocene or Early Holocene" (Gill 1965), to 3 to 4 million years ago (Fleischer, Price, and Woods 1969), there is at present considerable disagreement in this matter, and the view that Australites fell at the same time as the Southeast Asian tektites and thus belong to the same strewn-field is not shared by all scholars.

In any case, the Australasian tektites are the only ones whose fall may possibly have been observed by early man, either by Pithecanthropus groups in the northern and central zones of the strewn-field, or, if a later date for the Australites is accepted, also by early Australian Aborigines in the southern zone. This possibility is vividly

described by Chapman (1971), who tells how, looking understandably scared, Java Man stared from under his heavy eye-ridges at the silvery glittering cloud in the sky which became bigger and bigger as it approached earth; and then listened in awe for half a day to the frightening noise of millions of these glass balls raining down through the atmosphere and hitting the soil, the rocks, the trees, and everything around him.

Unfortunately there is little hope of finding any record of this event, unique and truly impressive as it must have been, although Java Man may have talked about it for generations. If, on the other hand, a tektite fall really did occur only a few thousand years ago in Australia, it would not be unreasonable to expect this to have been represented in rock paintings and the like, and such a record to be discovered one day. Almost half a century ago, Fromaget thought he found faint memories of the tektite fall in local Vietnamese and south Chinese myths, causing him to place it in the Neolithic (Fromaget 1932: 59).

What we can hope, however, is to find tektites associated with, and thus able to date, the tools or remains of early man, or the faunal remains of that time. In other words, we can hope to be able to use tektites as chronological markers, which would be all the more welcome as other methods for arriving at an absolute chronology in the 700,000 year range are notoriously unreliable. This possibility was foreseen by Beyer, von Koenigswald, and Saurin with regard to Southeast Asian tektites (called collectively *Indomalaysianites* by Beyer) long before they were absolutely dated, and a Middle or Early-Middle Pleistocene date for strata thus marked by tektites was assumed (Beyer 1956: 399). There was some disagreement, though. Whereas in 1964 Beyer still considered these tektites to be only 300,000 years old (personal communication), Saurin thought in terms of 600,000 years (1966: 99). Now that the revised potassium-argon and the fission track dates for Southeast Asian tektites are available, all those industries or human remains found in association (direct or indirect) with tektites in the central and northern zones of the Australasian strewn-field can be confidently dated to about 700,000 years ago. [See Tom Harrisson's qualification to this statement, "Tektites as 'date markers' in Borneo and elsewhere." *AP* 18(1): 61-63, 1974. Ed.] These include *Pithecanthropus erectus* in Java (von Koenigswald 1968: 199-200); the Cabalwanian of northern Luzon, also found by von Koenigswald (1958) in association with tektites; Palaeolithic industries in the Philippines (Beyer 1947: 239); and Palaeolithic industries of Cambodia and by extension (according to Saurin) the industries of the so-called Chopper-Chopping-tool complex (Soanian, Anyathian, Choukoutianian, Patjitanian, Tampanian, and so forth) (Saurin 1966: 108). If a direct datable association of tektites with Palaeolithic industries or human remains has not yet been observed in Thailand, the chances are that this may soon happen.

DISCOVERY OF A NEW TEKTITE FIELD ON THE NORTHWESTERN RIM OF THE AUSTRALASIAN STREWN-FIELD

The latest detailed map of the distribution of *Indochininites* (Fig. 1), that is, tektites found on the Indochinese peninsula (including Thailand), that by Barnes (1963: 34) of the northwesternmost part of the Australasian strewn-field (and of its northern zone), shows quite definite limits to this field in the form of a line going in a southwest-



Fig. 1 Distribution of tektites in Mainland Southeast Asia. Source: John A. O'Keefe, ed., *Tektites*, p. 34, Fig. 7. © 1963 by The University of Chicago Press. (Khok Charoen site added.)

northeast direction from Kanchanaburi in western Thailand through central Thailand, Laos, and North Vietnam on to the site of Dong Van on the Sino-Vietnamese border and then into southern China. Only one tektite site, that of Chiang Rai in northern Thailand, lies outside (i.e., northwest of) this line.

Except for Kanchanaburi in the western mountain range, no site in central Thailand appears on this map. However, during excavations by the Thai-British Archaeological Expedition 1966-70 at the Khok Charoen site, numerous tektites were discovered and information was gathered about other tektite sites in the area. The Khok Charoen site is situated approximately 13.5 km north of the town of Chai Badan and belongs to *tambon* (subdistrict) Bua Chum, *amphoe* (district) Chai Badan, Lopburi Province.

At the site itself, in an area of approximately 1500 m², 7 tektites were found on the surface (Plate Ia): 1 rather large (10 cm long) "dumbbell"-shaped tektite weighing 167 g, and 6 walnut-, almond-, or hazelnut-shaped (and sized) tektites with weights ranging from 48 to 6 g. The average weight of this small collection was thus 42 g including the big one, 22 g without it.

As soon as it became known that we were interested in these strange small black things, people flocked in to offer tektites for sale or examination. Obviously everyone in the area is collecting tektites and attaching value to them for some reason. Thus a farmer from a village about 3 km from there showed us an almost spherical tektite he had found in his fields, which was about 5 cm in diameter and 3.6 cm thick. Local boys sold us a rather big, elongated (almost cylindrical) tektite of approximately $8 \times 2.7 \times 2.3$ cm, and a smaller one which they had broken with a hammer "to see what was inside" (nothing). Similarly, a monk from the nearby Vat Nikom Boromothavhad visited the site and showed us a tektite collected near the monastery, which he had broken in half using a steel knife and a hammer.

Finally, a villager from Ban Dong Noi, 3 km southwest of the Khok Charoen site and belonging to the same *tambon* Bua Chum, brought a bag of tektites which he said he had collected over the previous 3 years from his field of around 75 *rai* (Plate Ib). One *rai* being 1.6 ha (1600 m²), this would correspond to about 120 ha. The collection comprises 43 items weighing 600 g, ranging from a tektite in the form of a flattened sphere of $4.5 \times 4.2 \times 2.5$ cm, weighing 100 g, to a less-than-hazelnut-sized bit of less than 3 g. The average weight is 14 g. The forms are mainly walnut- or almond-like, or flattened spheroids. Two of the smallest tektites show limestone incrustations, which is not astonishing as the soil in this area is full of limestone concretions and is laid on limestone bedrock which at places comes up very close to the present surface. There is also 1 small tektite which looks drop-shaped, and another which may also have been drop-shaped before the thin part was broken off (ancient break, not new). Five other specimens from this collection seem to be fragments of "hollow Indochinites," as they display concavities. No "navels" or "worm-like" cavities of the type characteristic of Billitonites (von Koenigswald 1961: 320) are present, except perhaps in such a subdued form that they are not recognizable.

On the whole, therefore, this particular collection of Khok Charoen-Ban Dong Noi tektites, which can reasonably be taken as quite representative of tektites found in the area, is remarkably similar to tektites found in Luzon (*Rizalites*) (see Beyer

1962: pls. 23 and 34-35) rather than to the "Characteristic Indochinites" (Beyer 1962: pls. 17-19), which are thought to be the dumbbell- and drop-shaped tektites.

Further information with regard to the occurrence of tektites in Thailand, gathered on the same occasion, is mentioned here for what it is worth.

When the French construction firm CITRA was upgrading the road from Chai Badan to Nakhon Ratchasima in the late 1960s, their main road-building material, a sort of laterite, came from a quarry situated 19 km north of Si Khiu, 1 km east of the road from there to Nong Bua Khok. Si Khiu itself is an important station on the Bangkok-Sara Buri-Nakhon Ratchasima railway about 40 km before the terminus. This quarry, now referred to by the local people as "site km 19" in accordance with CITRA terminology (it is in fact not far from a village called Ban Non Pradu, and this may be a more appropriate designation), is thus situated about 40 km as the crow flies WNW of Nakhon Ratchasima. Here, I was told by CITRA engineers and workmen, hundreds of tektites came to light when the layer (from 50 cm to 2 m thick) overlaying the laterite was removed. These tektites thus came from *above* the laterite. This contrasts with the observations of Lacroix (1935: 2130), who found tektites at Muong Nong in Laos in the upper 10 cm of a lateritic clay which was overlaid by an alluvial layer about 1 m thick, and of Barnes and Pitakpaivan (1962), who in three sites out of four in northeastern Thailand also found Muong Nong-type tektites *in* laterite beneath other layers of soil. Since the latter two suggest that Muong Nong-type ("Layered Indochinites") and ordinary tektites ("Shaped Indochinites") have both been formed by the same event, namely, the head-on impact of a comet with subsequent formation of puddles of molten soil (Barnes 1971), this difference in location is intriguing.

Be this as it may, these tektites from Ban Non Pradu seem to include a fairly high proportion of rather large specimens. I have myself seen one in the possession of a CITRA engineer, which is in the form of a flattened sphere and measures almost 8 cm across; and people in the Si Khiu area who, I am told, all collect tektites, are said in some cases to possess tektites "as big as a fist." No artificially flaked fragments of a corresponding size have been found, but the possibility that prehistoric man in the area produced blades up to 10 cm in length from such tektites must not be overlooked; indeed, if such blades were found, they would probably be automatically classed as "obsidian" by the excavators.

BELIEFS AND CUSTOMS CONCERNING TEKTITES IN THAILAND TODAY

Before I describe the more significant finds of tektites at the Khok Charoen site, namely of tektite flakes and fragments, a few words about current beliefs and customs in this area concerning tektites may be of some relevance.

The name for tektites, in this northeastern part of central Thailand at least, is *sakèd daaw*, or "Star Flake or Fragment." This in itself shows the popular belief in the cosmic origin of these glassy objects, here as in other parts of the Australasian strewn-field if not in other strewn-fields as well. That tektites have fallen from the sky is in fact a commonly held belief the world over (Beyer 1956: 391 ff.) similar to that regarding prehistoric stone tools as being "thunderbolts" and the like.

Because of their heavenly origin, tektites are used by almost everybody in the area in which they occur in this part of Thailand (and well beyond) as amulets or

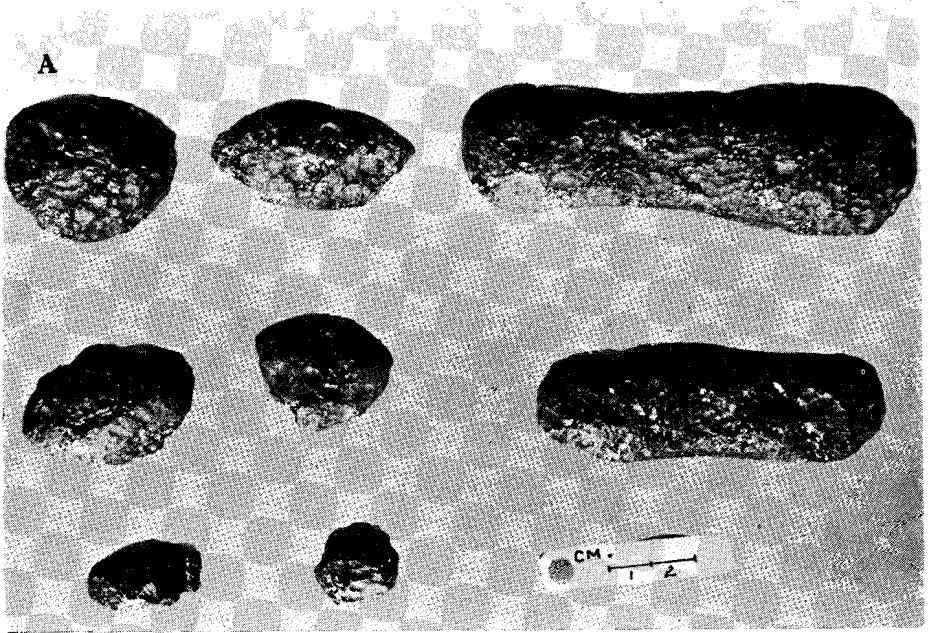


Plate 1a Whole tektites found on the surface at or near Khok Charoen site, including two unusually large ones. Photograph: Visual Aids Unit, Australian National University, Canberra.

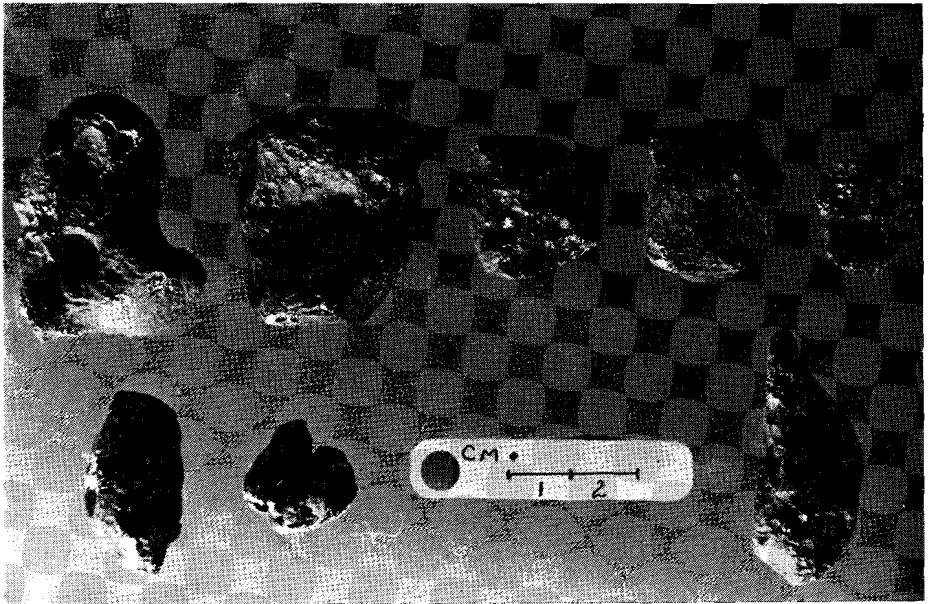


Plate 1b Fragments of hollow "Indochinites" and a drop-shaped tektite from Ban Dong Noi (adjacent to Khok Charoen); on the whole, the Ban Dong Noi collection consists, however, overwhelmingly (35 items as against 8) of nut-shaped tektites as depicted on the left side of the plate above. Photograph: Visual Aids Unit, Australian National University, Canberra.

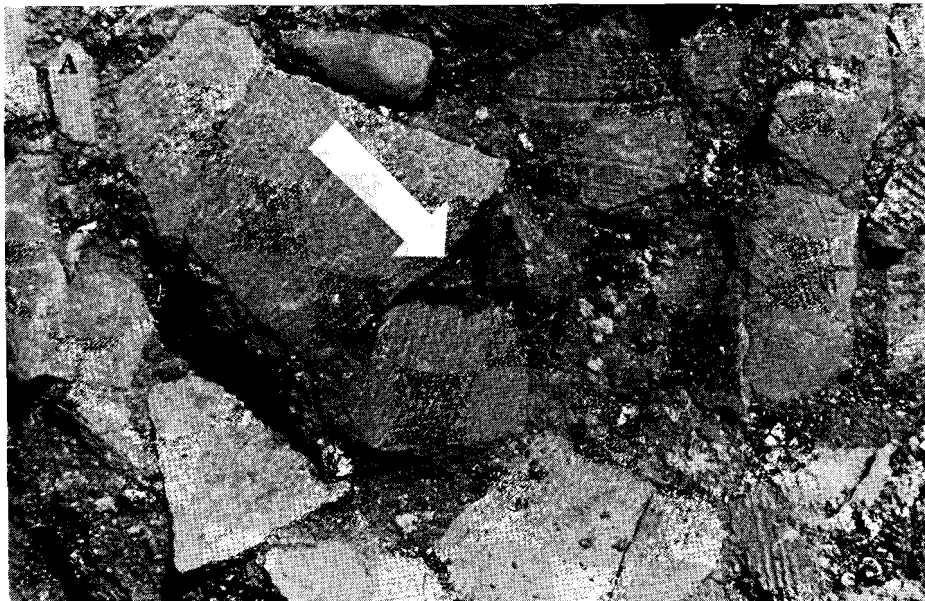


Plate IIa Tektite flake *in situ* on collapsed pot (large decorated bowl with four small legs) between feet of Burial 9, Khok Charoen 3. It is unlikely that this flake belonged originally to Burial 9 as it was found lying on the outside of the pot.



Plate IIb A possibly retouched tektite flake from the Khok Charoen site.

talismans. As such they are incorporated into the popular Buddhist system of beliefs and associated with the small Buddhist votive tablets many people here wear on chains around their necks. (There are even Buddha images made of tektites [Boeles, personal communication, 1968].) Indeed, I have often noticed tektites or tektite fragments being worn in this way, either alone or together with Buddhist amulets, neatly encased in tiny plastic containers or wire-mesh bags. When asked for the reason, the answer is inevitably "for protection." As the *Nai Amphoe* (District Chief) of Chai Badan put it very succinctly: "Tektites protect because they are parts of stars; this is an ancient Indian belief." Or, in the words of a local resident: "If I wear this *sakèd daaw*, nobody can beat me, nobody can hit me, nobody can stab me."

Closely linked with the use of tektites as amulets in Thailand today is their use, mainly polished or cut, in jewelry. Indeed I suspect that generally speaking the reason for wearing tektites in rings, earrings, and pendants is here precisely the same as for wearing them as amulets, although this is not always readily admitted.

Like various popular beliefs regarding tektites, the custom of using them for jewelry also seems to be worldwide, especially in those regions where tektites occur. A 17th-century tektite ring from Indonesia was published some years ago (Begg 1967). From the work by Suess (1900) (quoted by Gentner [1964: 92]), we know that "in former times" many Moldavites were sold by the farmers who found them in their fields to merchants in the jewelry business. At the time of the Agricultural Jubilee Exhibition in Prague in 1890, the craze for jewelry made of Moldavites had reached such proportions that jewellers paid 40–50 *gulden* for 1 kg of unworked Moldavites, surely a considerable sum at the time. This ties up with what I heard a few years ago, which was that West German jewelers were buying tektites (presumably of the Muong Nong type) from northeastern Thailand *by the ton* for the European trade. Finally, William G. Beyer, the son of the great tektitologist H. Otley Beyer, told me that his father had given a pair of earrings made of tektites to the First Lady of the Philippines, Mrs. Marcos, which she often wore, and that Queen Elizabeth II also had a Philippine tektite in a pendant or a brooch; so far, however, I have been unable to check this information.

FINDS OF TEKTITE IMPLEMENTS AT THE KHOK CHAROEN SITE

As mentioned earlier, numerous tektite flakes and fragments were found during excavations at Khok Charoen in addition to the few whole tektites found on the surface. During the four excavation seasons at this site, altogether forty-one 4×4 m pits were excavated, although not all to the full depth or full extent of 4×4 m. The excavated area thus covered at the most about 600 m², down to depths varying from about 40 cm to 1 m, or, very roughly, 400 m³. Six whole tektites, 30 tektite fragments, and 75 tektite flakes were recorded in this area (Plate IIa–b). It must be added, however, that the real number of these must have been appreciably higher, as obviously many of the smaller flakes could have escaped attention, while some of the bigger tektite fragments or whole tektites, on the other hand, were discovered to have found their way into the pockets of our local workmen, for obvious reasons.

While it is not difficult to distinguish between a whole tektite and a broken one,

it is in some cases downright impossible to separate manmade "flakes" from the "fragments" which are either the waste product of flake-making or natural fragments. If the possibility of the natural breaking of tektites (through impact?) is accepted, then so too must that of natural flaking, and this latter problem seems to have attracted little research so far. Although there is evidence for some tektites (Indochinites from Dalat, South Vietnam) having undergone impact in a semiplastic state (Nininger and Huss 1967), no such evidence is forthcoming from the overwhelming majority of tektites in the northern zone of the Australasian strewn-field. The impact of these hard, though hot, glass bodies on rock or any hard surface must inevitably have resulted in breaking *and flaking*, as can easily be demonstrated by throwing an ordinary tektite with moderate force onto a concrete floor. This is not inconsistent with Baker's assertion (1958: 371) that Australites "descended through the denser, lower layers of the atmosphere at such reduced speeds that they landed without being smashed to pieces on contacting hard ground." For if we accept the theory of von Koenigswald (1967) mentioned earlier, tektites in the northern zone of the strewn-field would have entered the earth's atmosphere at a steeper angle and thus impacted at a higher speed than Australites.

In fact Nininger and Huss (1967) estimate that two-thirds of all the 40,000 Indochinites they inspected showed breakage, and an even larger percentage showed splintering or chipping. The high proportion of tektite flakes to whole tektites reported by Beyer (1947, 1956, 1962) from various sites in the Philippines, where the former often occurred in association with the far more numerous obsidian or flint implements (flakes), seems to indicate that most of the tektite flakes were naturally flaked, as other more suitable raw material was readily available and there was no technological necessity to fall back on tektites which are obviously more difficult to work than bigger lumps of flint or obsidian.

But since it is generally believed that the sculpturing of the surface of Southeast Asian tektites is due to the action of soil acids, it could be argued that flakes with absolutely smooth surfaces (other than the bit of cortex they may show) cannot possibly be the result of impact flaking, for if they were they would have remained in the soil for the same period as the whole tektites and would thus have been attacked by the acids in the same manner. To this, Nininger and Huss (1967), as well as O'Keefe (1967), answer that there is now sufficient evidence to confirm the thesis originally put forward by Suess at the beginning of the century that the sculpturing of tektites results from aerial ablation or aerodynamic processes rather than from some sort of corrosion process in the soil. In other words, the tektite must have arrived on earth (and in Southeast Asia in particular) in its characteristic sculptured form, and if it broke on impact, the surface of the fragments would be smooth.

The only attempt to clarify this matter that I know of was made by Stuart Scott (personal communication, 1967), an American geologist working in the mid 1960s on a development project in greater Manila (at Mandaluyong, a little more than 1 km east of the crossing of Highway 54 and Shaw Boulevard). Seeing tektites and tektite flakes (but no other archaeological remains) being dug up from about 1.20 to 1.50 m deep when a trench was excavated, he concluded that the flakes must be natural, and carefully sifted through 1 m³ of this tektite-bearing soil to find the proportion of flakes to whole tektites. The result was a large amount ("a cupful")

of flakes to only 6 entire tektites: a proportion similar, in fact, to that found at the Khok Charoen site in Thailand. The presence of so many tektite flakes and fragments (Scott did not differentiate between the two) with smooth surfaces in an otherwise sterile deposit, that is, one which shows no signs of prehistoric human occupation, can be seen as a confirmation of the assumption that these flakes are natural ones.

There remains of course the problem of the fractured Hollow Indochinites which show almost as much sculpturing on the breaks and even on the inside as on the outside. They must thus have broken up before impact or been submitted to some action afterward which spared other Indochinites. No attempt is being made here to solve this problem.

The classification of the Khok Charoen finds as "fragments" and "flakes" is thus somewhat ambiguous, and is not to be understood as implying that all flakes were intentionally flaked or that all fragments must be the result of such flaking. On the contrary, I suggest that the majority of the tektite flakes and fragments found at Khok Charoen are natural ones. More still, that it was the discovery of such flakes (which he may have used as he found them) which gave prehistoric man in this part of the world the idea of himself flaking tektites if no other suitable material for the manufacture of certain tools was at hand, as was the case in the Khok Charoen area.

However, the fact that some flakes at least are manmade is well established (Roe, personal communication, 1968), although it is impossible to say with certainty exactly how many. In order to find out more about the nature of these flakes, 10 flakes of various shapes and sizes, manmade or not, excavated during the third season at Khok Charoen and selected more or less at random (except that they did not come from the upper layers), were submitted to C. B. H. McBurney of Cambridge University who kindly agreed to examine them according to the method developed by Semenov (1964). This method consists of coating the surface of the specimen with silver, which gives definition to details of the microrelief, and observing it through a binocular microscope. The results are summarized below.

There are three types of features:

1. Those due to the process of fracture—parallel ridges, radial scars, and so forth. See the photograph of the fresh tektite flake, Experimental flake no. 3 (Plate III*a*).
2. Short scratches with irregular bottoms (plus some longer versions) and other pits and depressions of various shapes and sizes. See Tektite flake 5 (Plate III*b*). These may be of mechanical, chemical, or organic origin, subsequent to the fracture.
3. Scratches, V-shape in cross-section and longer than those in the previous group (Plate III*c*). These occur in groups, either in varying directions or in parallel. It is these which may be considered as wear, because of their shape, size, and regular grouping (see Plate III*d* for similar microwear on a chert flake). Groups (1) and (2) are common to all the flakes in varying degrees, but group (3) is restricted to flakes 1, 2, 3, 5, 6, 7, 8, and 9.

After having thus found out that fully 80 percent of the specimens in this sample (which cannot, however, be taken to reflect the overall situation) show signs of wear,

that is, use, the questions now arise: When, how, and for what purpose were these flakes used?

ANTIQUITY OF THE USED KHOK CHAROEN TEKTITE FLAKES

The best answer to the question of when these flakes were manufactured and used would of course be given by their direct and absolute dating by such means as the obsidian-hydration dating method. Unfortunately, this method did not bring forth any results when applied to Khok Charoen specimens, mainly because, unlike obsidian, tektites are essentially anhydrous—they neither contain nor absorb water. The reasons for the failure, or rather inapplicability, of the hydration dating method are set out in the appendix by Ambrose. However, Barnes and Russell (1966) have reported that some tektites do contain a trace of water, which may indicate that they can also absorb it, if only in extremely small quantities. It is therefore hoped that, with the increasing refinement of measuring techniques, it will one day be possible to date tektite flakes in Southeast Asia, like obsidian flakes, by determining the time at which the surface of the flake was first exposed to air; if the (used) flake is a natural one, the likely date thus obtained would be 700,000 years ago, which would not give much indication as to the time it was first used.

Failing, at least for the time being, the direct dating method, an indirect one must be used. The most promising way would be associating these flakes with other dated artifacts or human remains, with datable archaeological layers or with some material which could be carbon dated. Again, unfortunately, no such association could be observed at the Khok Charoen site. This site is essentially a Neolithic (or at least locally pre-Metal) burial ground with sixty-odd recorded burials (for the last preliminary report see Loofs 1970). These burials are not yet dated with precision. There are at least two burial periods, and dates in the second or possibly the late third millennium appear reasonable. But there are also signs of subsequent habitation on the site, provisionally dated to the later parts of the first millennium B.C. and the first centuries A.D.

As no watertight case can be made for the association of any of the tektite flakes, fragments, or whole tektites found on the site with any of the burials, whether as grave goods or as belonging to the group(s) whose dead are buried here (although some such flakes were discovered lying very close to skeletons), it must be assumed that they were used by those who inhabited the area well after the time of the burials. The problem of dating the use of the flakes is all the more difficult to solve as there is evidence for large-scale erosion at the site at an unknown date. Most burials have obviously been partly exposed for long periods before being covered up again by soil accumulation, and this cycle may have been repeated one or more times, including during the period following the post-burial occupation, as many artifacts clearly belonging to the latter have been found at burial level as well as throughout the deposit and on the present surface. The effect of these soil movements on such highly mobile objects as small tektite flakes can easily be imagined—they too are now found everywhere, and there is absolutely no stratigraphical evidence usable for dating them. If, as is believed, many of these flakes are natural flakes, one could even expect to find unused ones in the original fill of the burials.

Beyer, who claims to have excavated or found many used tektite flakes at sites in Luzon, Philippines, dates them to the local Mesolithic or Neolithic, mainly on the

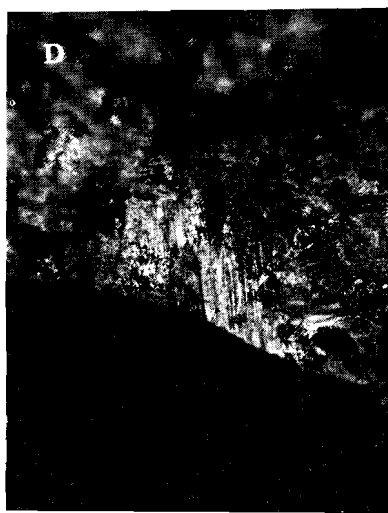
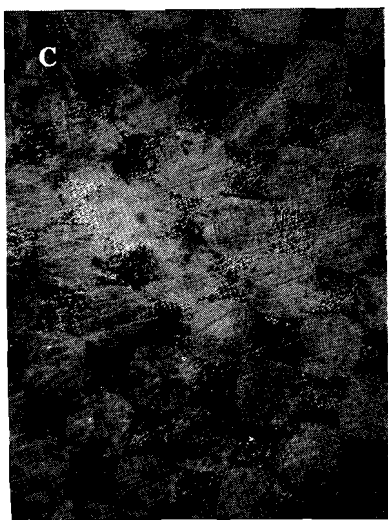
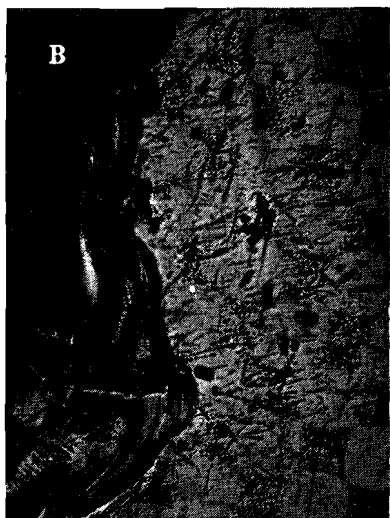
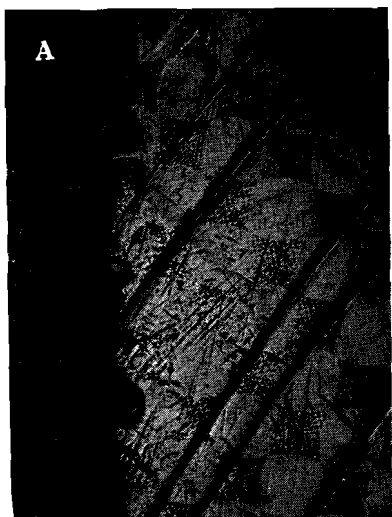


Plate III *a*, micro-photo ($\times 100$) of tektite flake 3, area 1 (as example for micro-relief features of group 1, i.e., those due to the process of fracture). Photograph: C. B. M. McBurney, with kind permission. *b*, micro-photo ($\times 100$) of tektite flake 5, area 1 (as example for micro-relief features of group 2, i.e., those of mechanical, chemical, or organic origin, subsequent to the fracture). Photograph: C. B. M. McBurney, with kind permission. *c*, micro-photo ($\times 100$) of tektite flake 2, area 1 (as example for micro-relief features of group 3, i.e., those which can be considered as due to wear and use). Photograph: C. B. M. McBurney, with kind permission. *d*, micro-photo ($\times 100$) of chert flake, area 1 (for comparison). Photograph: C. B. M. McBurney, with kind permission.

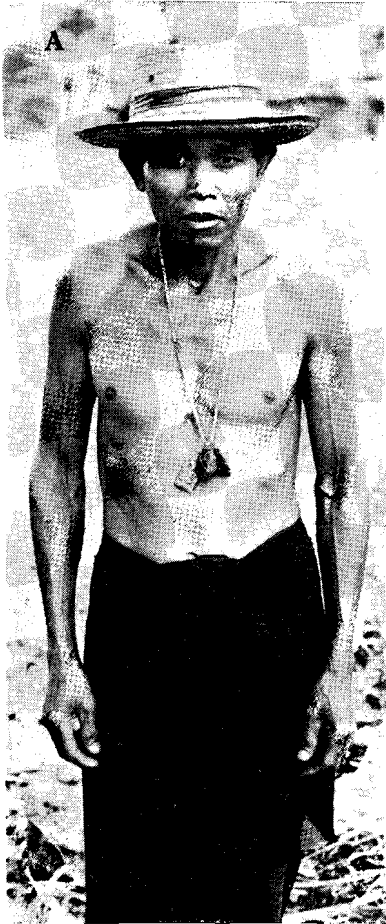


Plate IV*b* Experimental cutting of millet stalk with tektite flake.

Plate IV*a* Villager from near Khok Charoen site wearing tektite fragments or flakes as amulets together with and in the same way as a Buddhist amulet.

ground of their association with other artifacts (Beyer 1956: 401–406). He quotes cases of the use of tektites found locally, but also some where this raw material must have been transported over considerable distances (trade?), whether in the form of whole tektites or as flakes is not clear. No such trade need be assumed in Khok Charoen, which is in a natural tektite field, and there is no reason to believe that the tektite flakes were used here in pre-Neolithic or early Neolithic times. Also, the patination (thin on tektite flakes, thick on obsidian) commented on by Beyer and interpreted as a sign of great antiquity could not be observed on any of the Khok Charoen flakes.

Finds of artifacts made from Moldavites are of course well known and mentioned by all students of the use of tektites, the most detailed study being that by Skutil (1949). These finds are also dated to the Mesolithic and Neolithic, some even to the Palaeolithic. (The following unpublished finds, all from southern Bohemia, could be added [Žebera, personal communication, 1968]: a mesolithic micronucleus found on the Celtic *oppidum* at Třísov; some small retouched flakes from the early Mesolithic settlement at Černý Dub; and several retouched Moldavite fragments with strong patination found at Ločnice which are thought to be of Mousterian age.) Worked flakes of Libyan Desert glass, on the other hand, are dated to “Late Neolithic or pre-dynastic” (Clayton and Spencer 1934).

No comparative data are available from Thailand itself or from other parts of Mainland Southeast Asia. It seems that “obsidian” chips or flakes turned up in the upper layers (except for one or two found at greater depth) of the excavations at Non Nok Tha near Ban Na Di, Khon Kaen Province, northeastern Thailand (Parker, personal communication, 1968), although this has not been mentioned in any of the preliminary reports on this site. It is not clear whether they are artifacts or not. What is practically certain, however, given that the site is situated in the vicinity of several reported tektite fields, but far away from any known source of obsidian, is that these flakes are tektite flakes. A tektite fragment is mentioned and illustrated by Solheim and Gorman (1966: 176, pl. XXV, b) as a surface find from the neighboring site of Nam Pong 6 (Non Nok Tha was originally called Nam Pong 7); and the von Koenigswald tektite collection, now at the Senckenberg Museum, Frankfurt, West Germany, contains many tektite flakes from northeastern Thailand which are indistinguishable from those excavated at Khok Charoen. It is hoped that this matter will soon be investigated, so as possibly to provide the opportunity of a comparison with Khok Charoen.

FOR WHAT PURPOSE WERE THE KHOK CHAROEN FLAKES USED?

If comparative data relevant to the dating of the Khok Charoen flakes are scarce, those which have something to do with their use are plentiful. From central Europe, Australia, the Philippines, and even Thailand itself we have a number of suggestions, or of actual examples in the case of Australia, of the purposes for which tektite flakes were, and still are, used. Worked Moldavites thought to have been used in Palaeolithic, Mesolithic, or Neolithic times are usually looked upon as scrapers or similar implements. They are found in areas where other material such as silex for the manufacture of blades (i.e., cutting tools) is either available naturally or can be readily obtained. The same seems to be the case in the Philippines. Beyer

mentions the occurrence of large numbers of obsidian or silex implements, obviously mainly cutting tools, in association with the tektite ones he refers to as scrapers or, in some cases, arrowpoints. Australian Aborigines used and still use Australite flakes for this purpose in areas where other suitable material is scarce. However, Edwards (1966) stresses the very minor place Australite implements hold in the tool-kit of the South Australian Aborigines, mainly because of their small size and brittle nature, although there is evidence that Australite flakes set in bone have been used as cutting tools (see also Akerman 1975).

Nearer to Khok Charoen, in addition to the flakes from northeastern Thailand mentioned above, which may or may not have been used, the von Koenigswald collection also contains an obvious tektite implement from Thailand, of unknown provenance. It is a large oval Indochinite, about $7 \times 6 \times 2$ cm, one side of which is sharpened through flaking, while the rest is not worked and retains the cortex. When and for what this instrument was used is at present impossible to say; presumably as some sort of chopping-tool.

Unfortunately, all these "comparative data" are of little value, as they come from situations vastly different from that which must have prevailed in the Khok Charoen area at the time the tektite flakes were used there. We thus have to look at the problem of the use of the Khok Charoen flakes in isolation (or at the most in comparison with the present situation in the area) in two ways: by examining the flakes themselves, and by thinking about the technological requirements of the group using them. It must be kept in mind, however, that these implements—any implements for that matter—could be and probably were used for more than one purpose, just as we use a pocket knife to poke a hole in a leather belt, or as a scraper or screwdriver. All we can do here is to speculate about the most likely primary use (or one of them) of these flakes without in any way excluding the probability that they may have been used for all sorts of other purposes in addition.

Most of the flakes, whether manmade or natural, are rather thin with low edge-angles, and have a well-defined cutting edge produced by primary flaking. Many show some scars and traces of use visible to the naked eye such as broken edges, but rarely retouches. According to Derek Roe of Oxford, who kindly examined some of the Khok Charoen flakes, their forms suggest *cutting* as the primary function rather than scraping, piercing, and so forth (Roe, personal communication, 1968; also Wilmsen 1968). The groups of scratches observed by McBurney near the cutting edge of the flakes do not in themselves indicate for what sort of cutting action the flakes may have been used. However, these striations seem to be similar to those described by Semenov as being characteristic for reaping knives, although no sickle gloss, traces of hafting or other features usually associated with these implements could be observed on the Khok Charoen flakes. It must be assumed, therefore, that if the flakes were used as reaping knives they must have been simply held in the hand; most of them are just large enough to provide a good grip. That this is not an impossible assumption is attested by finds of obsidian flakes not larger than these tektite flakes in New Zealand and New Guinea which are also believed to have been used as simple cutting or shaving tools held in the hand (Ambrose 1973; Bellwood 1969). Obviously a tektite flake cannot be used for long as a reaping knife, as it becomes blunt after a while; presumably the flake was then discarded without having had time to acquire sickle gloss, and a new one used. But then

“obsidian tools [and probably also tektite flakes] . . . retain traces of work carried out for even a short time” (Semenov 1964: 15).

As said earlier, it is suggested that the users of the Khok Charoen tektite flakes occupied the site after the period of the Neolithic burials at a time which can best be called the proto-Bronze Age, since no bronze tools were found on the site or in the area, while bronze may well have been known by then in other parts of Thailand. Although there is no definite proof for it, it can be assumed that these people grew as a staple crop a cereal which could not have been wet rice on account of the undulating surface. At present this area, which was only resettled in the 1950s after apparently having been left unoccupied for almost 2000 years, as the absence of archaeological finds indicates, is famous for being an excellent millet-growing area. Most of the new settlers do in fact grow millet as a cash crop. It does not seem unreasonable to think of millet as the staple of the dwellers on the site 2000 years ago in preference to dry rice, which is not at present grown anywhere in the vicinity.

The stem of the millet plant with the ears of grain on top can only be broken off by hand when the seeds are absolutely ripe, when they would be likely to scatter all around and be difficult to retrieve. Therefore most millet growers prefer to harvest the grain before the top is ripe and to dry the ears for a few days in a flat place in front of the house, which can be easily swept. In this case a very sharp cutting tool is needed to cut the stem, which is still rather tough and fibrous. At the present time iron sickles or simply knives are used in this area, but in pre-Metal times it must have been very difficult to find tools sharp enough for this purpose. No fine-grained rock from which tools of this sharpness could be manufactured is known from the Khok Charoen area. From the smallness of the stone adzes found at the site it would appear that even stone not hard enough to produce reaping knives was a scarce raw material. This is also borne out by the fact that only a few very small lumps of stone from which such adzes could be manufactured were found on the site, and that several limestone adzes (too soft to have been used) were discovered in the burials, suggesting that the real thing was considered too precious to be wasted as a burial gift.

People in this area must therefore have been looking for a raw material for the manufacture of cutting implements, and tektites would have appeared to them as literally heaven-sent. If they found sharp tektite flakes, they probably used them, and they may also have flaked whole tektites in order to obtain sharp flakes to be used as reaping knives.

But there is more to it than that. As stated earlier, people in Thailand today consider tektites to be something supernatural, parts of stars fallen on earth to be used as amulets for protection and so forth. It is likely that prehistoric man looked upon tektites in a similar way, while at the same time manufacturing or using implements from them. But rather than seeing these two uses as mutually exclusive, as seems to be the case with South Australian Aborigines at present, among whom only unworked Australites are used for magical purposes (Edwards 1966) whereas implements made from Australites apparently have no magical properties, there is no reason for not suggesting that it could have been otherwise elsewhere and in the past. Cut and polished tektites made into jewelry in Thailand, for instance, seem to retain such properties, and I have myself seen tektite flakes or fragments being worn as amulets just as are whole tektites (Plate IVa). One could well imagine that

in Neolithic or early Metal Age Thailand implements made from tektites were considered to retain the supernatural qualities ascribed to tektites in general and that therefore such implements were used for special purposes in a magico-religious context. If comparison with contemporary rice-growing communities in Southeast Asia is of any value, such a context could be the growing and harvesting of the staple crop. Throughout Southeast Asia, rice plants are considered to have a soul, and in order not to frighten it when harvesting, the reaping knife must be small enough to be concealed in the hand.

We will of course never know for certain, but it could be that the occupants of the Khok Charoen site two thousand years ago believed in a "millet soul" and, so as not to frighten it, harvested millet by cutting it with small, heaven-sent tektite flakes (Plate IV*b*).

CONCLUSION

A great percentage of the tektite flakes excavated at the central Thai site of Khok Charoen were used in prehistoric or protohistoric times for an unknown technological purpose, presumably as cutting tools. It is suggested here that this use could have been, but not necessarily was, and certainly not necessarily exclusively, as a reaping knife for the manufacture of which there seems to have been no other material readily available in the area.

At any rate, whatever the purpose for which these flakes were used, it is clear that tektites must have played a role in the palaeotechnology of Thailand which is still insufficiently acknowledged. Greater attention to this should be paid in excavations in those areas of Thailand (and elsewhere within the Australasian strewn-field) where tektites occur, and the possibility should not be overlooked that small-, or even medium-sized, glassy fragments, flakes, and blades labelled "obsidian" may in reality be those of tektites.

APPENDIX

W. Ambrose

The visual similarity of tektites and Australites to obsidian has encouraged attempts to date tektites, used as flaked artifacts, in the same way that hydration-rate dating is made on obsidian. However, there has been no success in this direction.

Sections have been made of 5 tektite samples supplied by H. H. E. Loofs. Microscopic examination of these sections has failed to reveal any trace of a hydration rim, though other weathering effects are present. The evidence for chemical weathering is an etch pitting of some sections of the tektite surface. In obsidians the pitting is sometimes present with an absence of hydration, though more often the two effects occur together. The absence of hydration on tektites is problematic but is presumably due to chemical differences between them and obsidian. Obsidian may have more than twice the amount of sodium and potassium than tektites do, and both these glass-modifying elements are thought to assist hydration and weathering. Tektites have more than twice the usual amount of iron, magnesium, and calcium, elements which are likely to impede weathering and hydration in glass. Finally, obsidian always contains a small amount of water

whereas tektites are usually deficient in this. All these factors may contribute to the different weathering, and hydration, behavior of obsidians and tektites.

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