

# A Contribution to the Geoarchaeology of Truk, Micronesia

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**T**HE LOWER PARTS OF oceanic high islands are generally composed of tholeiite—a basalt characterized by relatively low potassium and relatively high aluminum content. They are petrographically similar to oceanic floor material and may or may not also contain serpentinites probably formed by hydration of tholeiitic material during tectonic movements.

The higher parts of oceanic high islands are more commonly alkali basalts, which are somewhat lower in silica content and appreciably richer in titanium, sodium, and potassium than tholeiites. Often further fractionation of the parent magma has given rise to lavas of even higher alkali content. Such rocks as rhyolites, trachytes, and phonolites are found on high islands as a result.

## TRUK GEOLOGY

In 1963 the United States Geological Survey published a study by Stark and Hay entitled *Geology and Petrography of Volcanic Rocks of the Truk Islands, East Caroline Islands*. Extensive use has been made of this study, the only text for Truk Lagoon geology available other than Stark et al. (1958), on which it was based. Fieldwork and petrographic study for and by me merely added a little to the several geological man-years of work which went into Stark and Hay (1963).

Their work, with that of earlier geologists, showed Truk Lagoon to be the semisubmerged remnant of a shield volcano formed by multiple extrusion of basic oceanic type lavas—dominantly basalts—from multiple vents. The mass was evidently catastrophically destroyed by Krakatoa-type explosions, as no trace of crater walls has been found.

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From a geoarchaeological viewpoint, Truk rocks are dominantly volcanic, unlike Yap, Palau, Guam, or Saipan. This is a help—but they are similar to the dominant volcanic rocks of Ponape and Kosrae (Kusaie). The volcanic rocks belong to one compositional suite—that is, they are quite distinctive—but within that suite lies a large number of petrographic types ranging from pyroclastics and sandstones through breccias to lava flows and scoria. This is also a help in that when any specific type or date of artifact is found made of only one rock type the source can probably be identified quite specifically.

#### ARTIFACTS

Fifty-five artifacts were examined. For their geographic locations, see Figure 1. They were:

1. pumice block from Fefan (Fritz A. Hartman);
2. three slingstones (Truk Handicrafts);
3. one adze, seven slingstones (Truk Tourism Office);

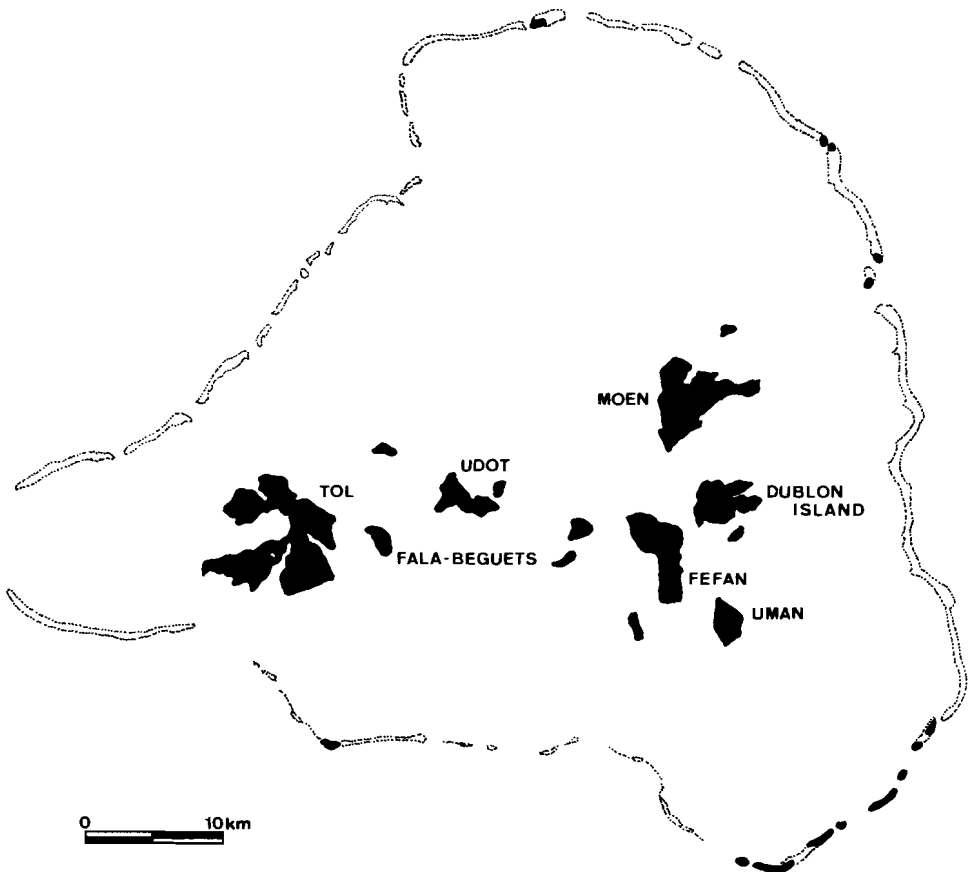


Fig. 1 Truk Atoll, East Caroline Islands.

4. thirty stones, mainly slingstones (Iras Village, Moen Island);
5. two slingstones from Tol (Francis Buekea);
6. three slingstones (one of shell) from Mechitiw, Moen (Jason Butler), see Plate I, *a* and *b*;
7. eleven slingstones (Smithsonian Institution) reported from Truk;
8. four specimens from Hawaii (Bishop Museum) reported from Truk.

Of these, the two slingstones from Tol and one slingstone from Mechitiw were taken for thin sectioning (see Appendix 1).

Many different oceanic basalt and oceanic andesite rocks appear to have been used and two types of aerated volcanic glass were noted—a dark one with an adamantine luster in the vesicles judged to be basaltic, called scoria, and a pale, light gray, faintly greasy luster one judged to be andesitic or rhyolitic and called pumice. Virtually all showed 1 percent to 5 percent magnetite, as did almost all of the rocks examined in the field.

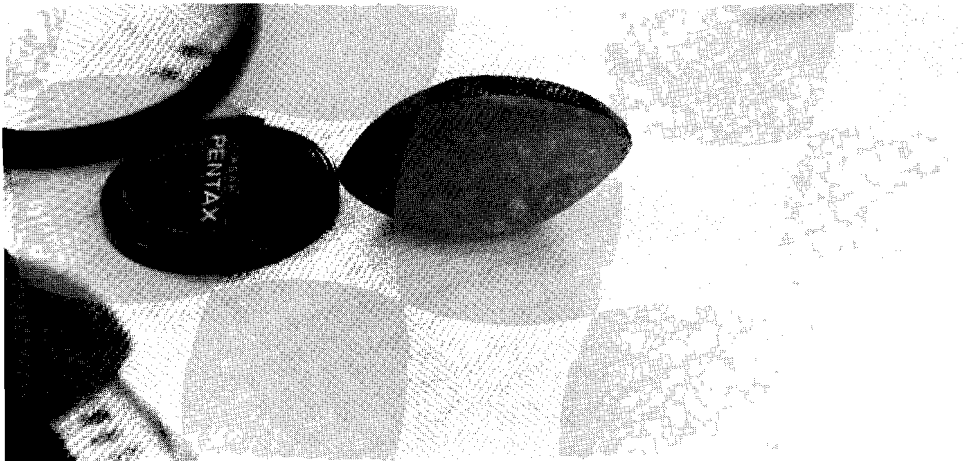
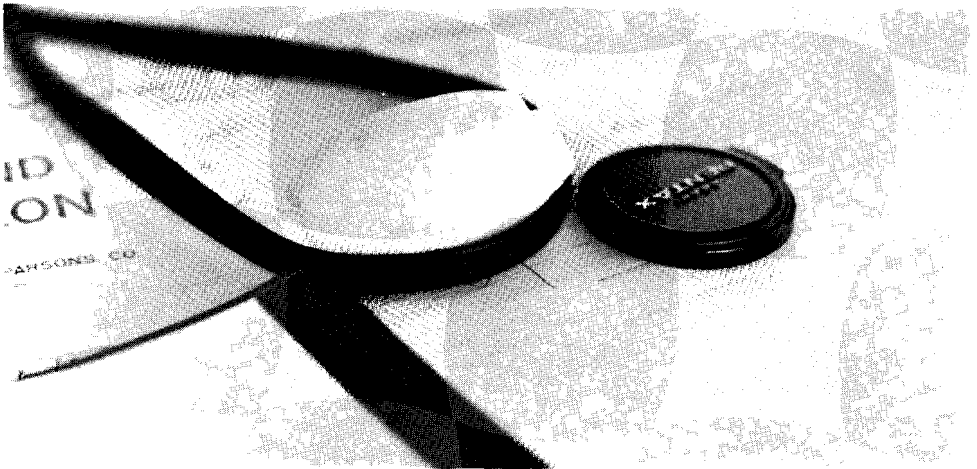


Plate I a. Shell slingstone. b. Two volcanic rock slingstones.

When the four specimens from Yoshiko Sinoto at the Bishop Museum in Hawaii were examined on Saipan, they were seen to be very different rocks. They were nonmagnetic, with two showing possibly metamorphic foliation (TP2-21; TP6-7). Recognizing that this may be a well-developed platy fracture in trachyte (cf., for example, Stark and Hay 1963:4-5; Bridge 1948:217), I suggest that further work be carried out on these specimens.

More than 100 stone artifacts are listed in manuscripts and reports on excavations on the island of Tol. As there are more than 4700 worked slingstones listed from the Marianas by Thompson (1932) in the Bishop Museum, inspection of these seems a logical follow-up for comparison purposes. Thompson (1932:50) notes clearly her understanding that the material fabricated appears to have been derived locally. I saw no reason to suspect otherwise for Truk excepting that attackers from one island fighting on another may be expected to introduce stones exotic to the battleground but indigenous to the atoll.

Unlike the Marianas, Truk seems to yield neither limestone nor pottery slingstones. Only one shell slingstone was seen (Plate Ia) on Truk, while Thompson's large Marianas collection (Thompson 1932:49) included fossilized coral and marble, as well as white limestone, but no shell slingstones. Truk-sourced stone artifacts should be easily distinguished from those of Yap. One line of approach would be to determine Cr, Co, and Ni values from various rocks and artifacts. Hawkins and Batiza (1977) state that the main rock type on Yap is a green schist which is quite distinctive and different from any rocks on Truk. They note, "The chemistry of these rocks, especially Mg, Cr, Ni and Co abundances suggest that the protolith was an ultramafic rock."

The pumice problem needs further work. Hartman's specimen and one from Iras are both remarkably pale in color to be of Trukese origin. Several geologists and others have commented on Andean pumice drifting westward across the Pacific Ocean from Central and South American volcanoes. My feeling is that the light-colored pumice is exotic to Truk and that an Andean source is likely.

Thin section and chemical analysis could be expected to rapidly deny or support the hypothesis that these artifacts are made from exotic rather than indigenous pumice. This approach, I think, would be less costly and faster than detailed mapping of Truk Atoll volcanics in a search for source. Stark and Hay (1963) make no mention of pumice in their study.

#### SEA LEVEL CHANGE

A fully professional major study of this problem was undertaken during the Scripps Institute of Oceanography *CARMARSEL* expedition in 1967. Relevant data were published by Bloom (1970), Shepard (1970), and Curray, Shepard, and Veeh (1970), but not generally publicized in archaeological circles. I satisfied myself that the near-shore geomorphology was consistent with the *CARMARSEL* report and observations.

Writing of Truk and Eniwetok lagoons, Shepard (1970:1910) says:

The result of this study seems to show that the basins are due primarily to solution of soluble limestone during stages of low sea level, whereas the hills are in part erosion remnants of the low stage solution and in part due to upward growing coral patch reefs during rising sea levels.

This statement clearly shows that Shepard believed that the lagoon bottom has sunk 10 to 20 fathoms (20–40 m), at least, since formation of the limestone, which was exposed and weathered to a karst topography, and is now the floor.

Bloom (1970:1895) gives other relevant details:

Radiocarbon dates from intertidal peat layers that overlie former hill slopes of weathered, volcanic rock demonstrate submergence decreased abruptly during the final 1.7 m of submergence, which permitted extensive progradation by tidal swamps over former reef flats or into former muddy estuaries. By this interpretation, submergence has averaged only about 0.4 m per 1000 years since 4100 years B.P., in contrast to the rate of 1.9 m per 1000 years between 4100 and 6500 years B.P.

Bloom's evidence of constant sinking includes a listing of "most of the common stratigraphic relationships on all of the high islands: mangrove peat over carbonate rock, freshwater peat over estuarine mud and freshwater peat or estuarine mud over a submerged bedrock slope" (1970:1896). As the radiocarbon dates used have not been corrected back to dendrochronological charts, the time spans may be slightly longer than quoted, but the conclusions hold.

Civil-engineering site investigations in the late 1970s on Truk included boring many short holes on Moen and Dublon. Relevant reports and data are summarized in Appendix 3 (see also Stone and Hansen 1977; Stone and Hultgren 1978). These investigations can be used cheaply and quickly to select sites for peat sampling to determine whether the peats revealed are brackish or fresh water in origin, and whether radiocarbon dating of the peats is necessary.

The bulldozing of shallow coral areas for road fill on the southeastern coast of Tol reportedly revealed peat under less than 1 m of water at low tide (personal communication with U.S. Air Force operators). My search for peat along 1½ miles of coastline with intermittent bulldozing failed. I did, however, find artifact CB-TO-8 (Plates II and III) during this work. If this is of Fefan Pottery Site age, the correlation with known data will be strong.

In a well-protected, semi-enclosed bay on Tol, several observations were made of basalt, with no coral or marine growth on it, dipping into the sea. If the land were rising, or the sea level oscillating over periods of a few hundred years, traces of coral or marine growth would be expected unless the present sea level corresponded with the maximum land sink/sea level rise. An apparent conflict is the discovery of a large number of slingstones in the shallow waters of Mechitiw, northwestern Moen. This is possibly the result of sixteenth-century battles rather than a 1 m sea level rise in this area over the last 600 years.

## CONCLUSIONS

1. Slingstones seen most probably were sourced at many small sites. This conclusion is drawn from the wide petrographic variation between the various stones, coupled with the close correlation between these lithologies and those of the Truk Islands. Clearly no one or two major quarry sources were utilized.

2. A slingstone's shape is dependent to a large degree on the lithology used. This conclusion is based on observation of flat sides on slingstones made of rocks with well-devel-

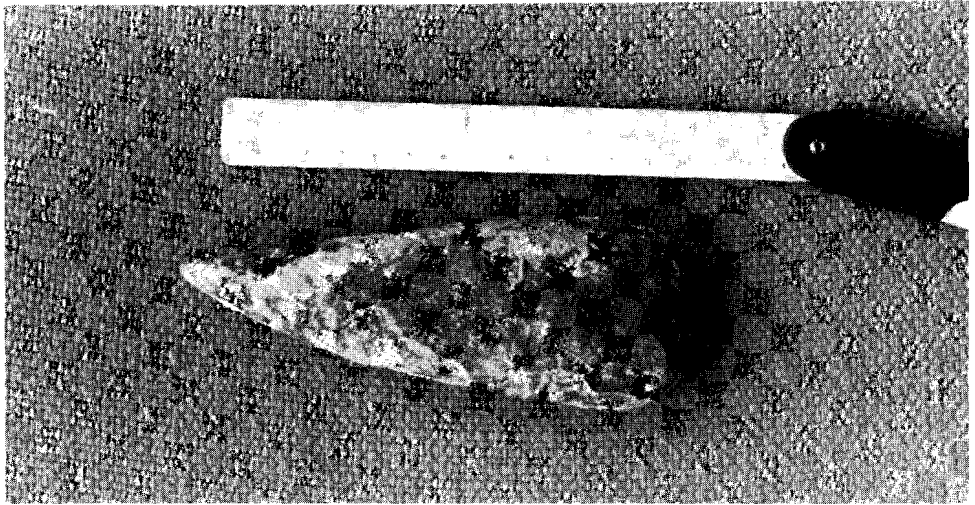


Plate II Side views of (?) adze CB-TO-8. Scale nearest object is in cm.

oped “jointing” or cleavage or Sander ‘S’ planes, and the long, thin shapes often adopted for rocks with well-developed cleavage.

3. The degree of polish seen on a slingstone is a reflection of the lithology used. Coarsely vesicular lavas take a poor polish. Coarsely crystalline rocks tend to break on crystal faces. Attempts to polish them would not be very successful. Finely crystalline, dense, compact, hard, tough rocks take a fine polish and such rocks used as slingstones commonly are polished well.

4. All slingstones seen could have been sourced on Kosrae or Ponape, but most likely were sourced on Truk. No slingstones seen (except for the shell one) have much chance of having been sourced on Guam, Saipan, Yap, or Palau. The rock types used for slingstones

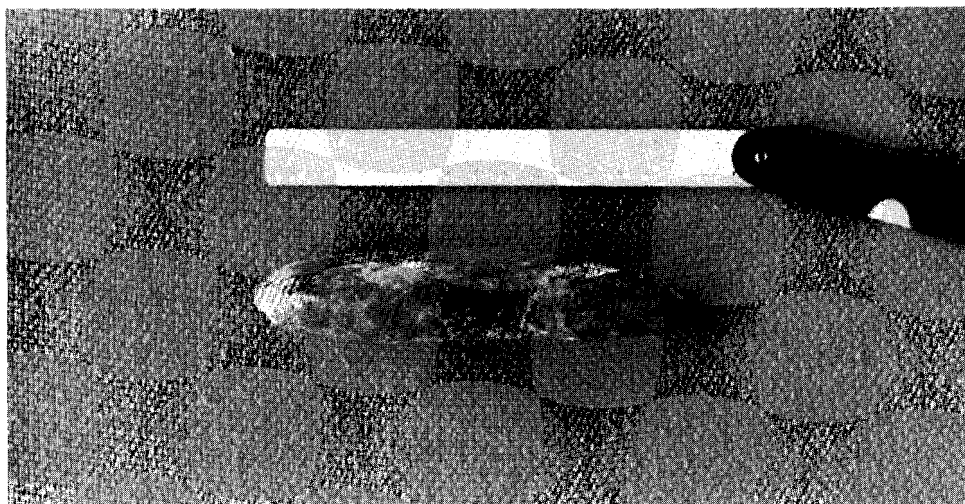
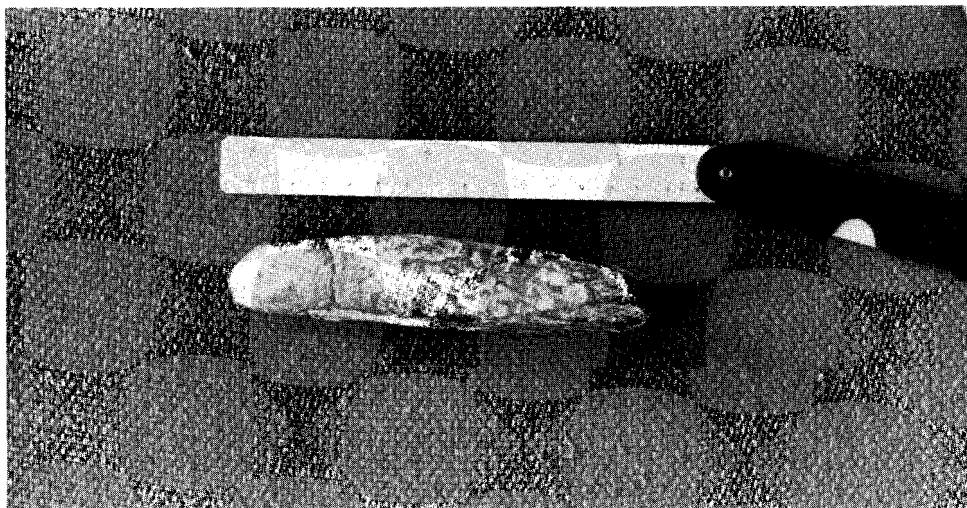


Plate III Edge views of (?) adze CB-TO-8.

were all seen during a brief field examination of Truk. They differ significantly from the rocks seen on Guam and Saipan and reported from Yap and Palau. They are generally similar to those seen on Ponape and reported from Kosrae.

5. Most of the Iras slingstones were quarried from sites on Mt. Tonnaachaw. Despite the fact that the northwest face of the mountain has been removed (King 1979:13), the rock types seen in the slingstones generally correlate very well with those seen in and near the present quarry.

6. Slingstones from Tol and Moen would be difficult to source accurately. Petrographic examination confirmed field observation and conclusion by U.S. Geological Survey geologists that many of the basalts on Moen and Tol are petrographically very similar.

7. Slingstone polishing and pointing techniques by rubbing in grooves and conical depressions were used. Examination of the ends of many slingstones indicates that this type of pointing is rare.

8. Artifacts from the Fefan pottery sites may include stone tools sourced from off-atoll. If this conclusion is correct, the 1200-1600 A.D. culture may have come from the east, while the B.C.-A.D. Fefan pottery culture more likely came from the west.

9. Sea level on Truk has been slowly rising over the last 2000 to 3000 years at the rate of about 0.4 m per year. This has been clearly shown by the *CARMARSEL* expedition.

#### ACKNOWLEDGMENTS

During a private visit to Truk in May 1979, I spoke with Tom King and his wife, Patricia Parker, who were conducting work in and near the proposed runway extension on Moen. When I asked about the source of the stone artifacts, King indicated that there was no geological work being done on them. When I indicated a willingness to donate time to such a study, he suggested that I make the offer to the Historic Preservation Office, Saipan, where he felt sure it would be favorably considered. During August 1979, I visited Saipan to raise the matter with Scott Russell and Ross Cordy. Following our discussion a proposal was prepared and submitted which resulted in a contract. This paper has been abstracted from the contract final report (Brooks 1980).

I wish to acknowledge the stimulation of Tom King, without whose interest this project would not have begun, and that from Scott Russell, Ross Cordy, and Dr. G. K. Ward. On Truk, Chief Camillo Noket of Iras Village, Moen, showed an understanding of the work and helped me to avoid pitfalls. His friendly hospitality to my wife and family is gratefully acknowledged. The Civil Action Team of the U.S. Air Force offered transport and accommodation in a difficult situation. Their comradeship as well as help is gratefully acknowledged. The Representative Officer in Charge of Construction (R.O.I.C.C.) Truk, Lt. O. E. Barfield, Jr. (USN) and P. Miller and J. Butler also rendered assistance. The Truk Historic Preservation Coordinator gave very freely of his time and was also of great help. My thanks go to the Smithsonian Institution and in particular to Douglas Ubelaker for the loan of slingstones for this work. The staff of the library of the Australian Mineral Foundation, Adelaide, South Australia were of immeasurable assistance, including their operation of the AUSINET and CSIRONET computerized data banks and their accessing U.S.A. data banks through the Midas Satellite. My thanks also go to AMF staff who prepared this report, and to my daughter L. E. E. Brooks who prepared the bibliography and assisted in proofreading and in final presentation.

#### APPENDIX I

##### *Report, CMS 80/9/26, by H. W. Fander*

Three examples of slingstones, and twelve rock specimens collected for comparison purposes, were thin-sectioned, petrologically examined, and compared. They are very briefly described below. Special care was taken to minimize wastage in cutting the slingstones.

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### A. *Slingstones*

*TO 1.* A vesicular porphyritic *basalt*, verging on dolerite, with andesine phenocrysts set in a fine to medium-grained random mass of fresh andesine laths, granular fresh pigeonite, and magnetite; secondary minerals comprise chlorite and traces of carbonate. There are no flow features. The rock is a typical tholeiite.

*TO 2.* A magnetite-rich, vesicular *basalt*, composed of thin labradorite laths, abundant skeletal/dendritic and euhedral magnetite, and minor granular pigeonite; all minerals are very fine-grained. There are no flow features. Classified as a tholeiitic basalt.

*MO 5.* A strongly flow-lineated amygdaloidal *basalt*, consisting mainly of subparallel fresh andesine laths, very abundant magnetite, granular and occasional microphenocrystal pigeonite, with irregular amygdales containing chlorite and carbonate.

### B. *Rock Samples*

*DU 1.* A largely glassy *lava*, suspected to be an under-saturated rock in the nature of a *leucite-basalt*. Extremely fine-grained indeterminate material, requiring chemical analysis for accurate evaluation. Differs considerably from all other rocks.

*DU 2.* Porphyritic *olivine basalt*, with phenocrysts of olivine, well-rounded Ti-augite, and fresh andesine, in a flow-aligned fine groundmass of short andesine laths, pyroxene, olivine, and magnetite.

*DU 3b.* Very similar to *DU 2*.

*DU 4.* Compositionally very similar to *DU 2* and *DU 3b*, but slightly coarser-grained, with more phenocrysts, particularly olivine.

*TO 3.* A flow-lineated amygdaloidal *basalt*, closely similar to *MO 5*.

*TO 4.* A porphyritic *nepheline-basalt*, with abundant fresh olivine phenocrysts and granular nepheline, set in a fine groundmass of microgranular clinopyroxene, magnetite and nepheline; feldspars are absent.

*TO 5.* Flow-lineated andesine *basalt* with very abundant small laths and a few microphenocrysts of fresh andesine, and interstitial microgranular magnetite and clinopyroxene. Quite similar to *MO 5* and *TO 3*.

*TO 6.* A faintly banded, amygdaloidal, nonporphyritic *basalt*, consisting of randomly oriented andesine laths, abundant fine magnetite, and many small spherical amygdales filled with carbonate and brown chlorite. The banding is textural.

*TO 9.* A porphyritic *basalt*, verging on dolerite, with phenocrysts of augite, labradorite, and occasional olivine, in a groundmass (fine- to medium-grained) of andesine, augite, and magnetite. Amygdales contain zeolites.

*MO 1.* Flow-lineated *basalt*; microphenocrysts set in a mass of subparallel andesine laths, microgranular clinopyroxene, and magnetite. Correlatable with *MO 5* and *TO 3*.

*MO 2.* Flow-lineated *leucobasalt* or *leuco-andesite*, composed dominantly of matted-parallel laths of oligoclase-andesine, with minor microgranular clinopyroxene and magnetite. Probably a feldspathic differentiate.

*MO 4.* A porphyritic *basalt*, with large fresh labradorite phenocrysts in a random, fine groundmass of andesine-labradorite, granular to euhedral augite, and magnetite. There

are occasional clay-filled amygdales. Broadly similar to *TO 1*, though with more phenocrysts and with minor compositional differences.

#### *Summary*

Some of the samples can be assigned to the "Tholeiitic Basalt" suite, and the remainder to the "Alkali Olivine Basalt" suite. A survey of reference literature indicates that both suites can, and do, occur in oceanic islands (e.g., Hawaii) and are often grouped as an "oceanic suite." Thus, in this respect, there is no major distinction between the slingstones and the rock samples. However, similarities between individual samples may be significant.

The clearest reference is Hatch, Wells, and Wells, *Petrology of the Igneous Rocks*, 12th edition (New York: Hafner Publishing Co., 1961), chapter 8 (pp. 335 ff.).

### APPENDIX II *Smithsonian Slingstones*

Eleven slingstones (U.S.N.M. cat. no. 420460) were loaned by the National Museum of Natural History, Smithsonian Institution, for nondestructive analysis. Descriptions of these slingstones follow:

NUMBER	SIZE(CM)	BRIEF DESCRIPTION
18	4.7 × 2.5 × 2.5	Highly polished basalt.
19	5.1 × 3.5 × 3.2	Volcanic.
20	7.5 × 4.0 × 3.2	Olivine basalt, very rude shape.
21	7.3 × 4.5 × 3.0	Broken-off sides. Lithology indeterminate due to organic cover.
22	5.5 × 3.4 × 2.4	Similar to 21, broken sides.
23	6.6 × 4.3 × 2.7	Gray basalt, irregular shape due to cleavage planes.
24	6.5 × 3.7 × 3.2	Basalt.
25	6.1 × 3.2 × 2.5	Very vesicular mid-gray basalt. Coarse vesicles to 3 mm. Broken side.
26	7.2 × 3.3 × 3.3	Gray vesicular basalt. White spots—later, organic.
27	6.8 × 3.8 × 3.2	?Lithology.
28	8.0 × 3.6 × 2.7	Very pale gray vesicular basalt.

Catalogued: 420460. Received November 1980. Examined under stereo-binocular microscope up to 40× magnification. Photographed.

### APPENDIX III *Truk Geological Studies: Annotations*

1. In January 1980, R.O.I.C.C. Truk made available to me one of 15 copies of an investigative report (1977) by R. L. Soroos and H. Hanson of Harding-Lawson Associates in Honolulu, for The Ralph M. Parsons Company/Austin, Tsutsumi & Assoc., Inc., A Joint Venture, on soil conditions at the construction site of Truk International Airport. It included the following:

*Borings*

- No. 29 east corner of apron
- No. 30 east of actual apron
- No. 33 adjacent to No. 29 to northeast (between No. 30 and No. 29)
- No. 41 west of centerline of apron
- No. 137 southernmost on apron

Five borings (29, 30, 33, 41, and 137) encountered one to three feet of highly compressible marsh soils consisting of soft silt and loose sand beneath the fill. The fill, and the marsh soils where they are present, are *underlain* by beach sand. Lagoon deposits were encountered *beneath* the beach sand at depths of eight feet or more in a few of the borings, indicating *emergence* not *submergence*—8 feet is equal to 2.5 m—maybe *earlier* than 6000 B.P. Note apparent contradictions with Bloom [1970].

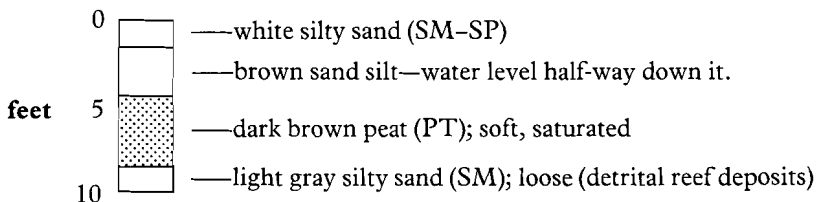
Approximate top of hole

- See Plate 4: No. 151 bottom of andesite at Reduced Level +30/110/140
  - No. 152 bottom of andesite at Reduced Level +70/100/170
  - No. 153 bottom of andesite at Reduced Level 0/140/140
- and Plates 55, 56, 57.

There seems to be no fault—just lava flow, at first submarine, then perhaps subaerial on irregular valley floor (C.C.B. 15/1/80).

- No. 128 20 feet of light gray, silty sand (lagoon deposits) (SP) overlying 15 feet of light brown sand (beach sand). Centerline of runway at N.E. end.
- No. 139 N.W. corner of apron. Collared @+4 dry gravel, silt, beach sand, lagoon deposits! *Ten feet indicating progradation* as in No. 142.
- No. 148 red-brown, gravelly soil/whole coralline LSM.

2. In January 1980, I also availed myself of a copy from R.O.I.C.C. Truk of an amendment (1978) to the original Soroos/Hanson report, by J. J. Stone and E. M. Hultgren. A description of a core follows. Collared @+4, behind (i.e., shoreward of) the '0' contour, is corrected to exclude the causeway.



Boring 11, Plate 12. Dark brown peat (4 feet) overlies light gray silty sand (SM). Loose (detrital reef deposits). Elevation collar +4.0, depth to top of peat 5+ feet, showing submergence *after* emergence (base of peat on detrital reef deposit). Need age dating—? Radiocarbon. Location of No. 11 on existing road adjacent to dock. \*N.N.B. Submergence 7+ feet indicated from submergence of base of peat.

3. In August 1977, J. J. Stone and H. Hanson of Harding-Lawson Associates in Honolulu prepared a report for The Ralph M. Parsons Company/Austin, Tsutsumi & Assoc., Inc., A Joint Venture, on soil conditions for dock and harbor improvements on Moen Island, Truk.

Plates 6-10: log of borings:

two onshore holes 5 × 15 feet deep (Nos. 47, 48)

two offshore holes each 45 feet deep

four offshore holes 15 to 30 feet deep (No. 156 is 23 feet deep)

There is no relevant data for sea level change investigation.

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