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SAND TEMPER IN PREHISTORIC POTSHERDS FROM THE TO'AGA SITE

W. R. DICKINSON

TWENTY-NINE REPRESENTATIVE sherds selected by T. L. Hunt from the collection of artifacts excavated at the To'aga site near the south coast of Ofu Island in the Manu'a Group of American Samoa were examined petrographically in thin section. As there is no current reason to suspect that any of the To'aga ceramic ware was made elsewhere, the purpose of the study was to provide baseline information about Manu'a temper sands. All the sherds examined contain volcanic sand as temper, although this basaltic detritus is mixed with calcareous grains derived from reef sources in some of the sherds. As would be predicted for Manu'a and other parts of Samoa, the volcanic sand is typical of the oceanic basalt tempers common to intra-oceanic Pacific archipelagoes (Dickinson and Shutler 1968, 1971, 1979). Several variants of temper sand are present in different sets of sherds, and available information is inadequate to pinpoint their respective sources. All could probably have been collected on Ofu or nearby Olosega Island, but derivation of some from Ta'u in Manu'a or even elsewhere in Samoa is not precluded by the petrographic data. Their petrologic compatibility with Samoan lavas, however, and their overall resemblance to the spectrum of basaltic tempers studied to date from Samoa, makes importation from outside Samoa quite unlikely. As none of the temper variants are identical to tempers known from Tutuila or 'Upolu, all are regarded provisionally as indigenous To'aga tempers, with the proviso that petrographic evidence alone cannot indicate how far afield ancient potters may have gone in their search for suitable clay and temper within Manu'a.

TO'AGA TEMPER VARIANTS

The following variants of basaltic temper sand are all present in varying numbers of To'aga sherds, and each is described in detail in subsequent passages:

(a) *Profuse Basaltic Temper:* Seven sherds (1-5, 7, 14) contain ferromagnesian basaltic sand so abundant that it forms 50-60 percent of the sherd bodies. The proportions of grain types in six (1-5, 7) of the sherds are statistically indistinguishable, but the seventh (14) contains a related volcanic sand of slightly different composition.

(b) *Sparse Basaltic Temper:* Twelve sherds (6, 10, 13, 16, 19-23, 27-29) contain sparse ferromagnesian basaltic sand of somewhat different composition and texture. The mineral and lithic grains form only 5-15 percent of the sherd bodies, but about a third (25-40 percent) of the temper grains used may have been fragments of broken pottery.

(c) *Feldspathic Basaltic Temper:* Three sherds (15, 17, 18) contain feldspathic basaltic sand, which forms a normal proportion (30-40 percent) of the sherd bodies and is both mineralogically and texturally distinct from the two ferromagnesian variants of To'aga temper. Another sherd (9) contains a similar but sparser temper sand (~15 percent of body) that appears to be a hybrid sand with a significant admixture of detritus from the kinds of bedrock sources that yielded the ferromagnesian basaltic sands.

(d) *Mixed Temper Sand:* Seven sherds (8, 11, 12, 24-26, 30) contain mixed temper sands composed of both basaltic and reef detritus in varying proportions. Ferromagnesian mineral grains and basaltic lithic fragments dominate the volcanic sand components of the mixed tempers, but their proportions are highly variable and plagioclase feldspar grains are also present in some sherds.

TEMPER GRAIN TYPES

The non-calcareous components of all the To'aga temper types are without exception composed of mineral grains and lithic fragments derived entirely from basaltic bedrock sources, either lavas or pyroclastic deposits, together in some cases with fragments of broken pottery. The mineral grains, originally phenocrysts or microphenocrysts in basalt, include clinopyroxene, olivine, opaque iron oxides (magnetite and/or ilmenite), and plagioclase feldspar. The lithic fragments, representing aphanitic groundmass of basaltic lava or tephra, display a spectrum of internal textures reflecting an inherent range of constituent grain sizes. Microphenocrysts in lithic fragments include all the mineral species that were also present in the temper sands as separate mineral grains.

Routine distinction between pyroxene and olivine in thin section was based upon key diagnostic features visible for each grain, and their identifications were checked by observations of optic axial angle and birefringence on suitably oriented grains. Pyroxene grains generally display faint green tints, and many show either cleavage or prismatic shapes. Untinted olivine grains are brighter in plane light, and many are altered along edges and fractures to bright reddish iddingsite. Most basalt lithic fragments have an intergranular internal texture, although the finest grained (here termed "tachylitic") are intersertal with plagioclase microlites set in black basaltic glass (tachylite). The coarsest grained (here termed "slabwork") display blocky to prismatic subhedral pyroxene crystals intergrown with aggregated and multiply twined plagioclase crystals of slablike aspect. Lithic fragments of intermediate grain size (here termed "lathwork") display disoriented mosaics of twinned plagioclase laths with equant and largely anhedral pyroxene grains within their interstices. As all gradations are seemingly present between "slabwork" and "lathwork" and "tachylitic" grains, the distinction made among them is useful in a qualitative sense only. Groundmass iron oxides in lithic fragments range from equant or granular to skeletal or elongate in form without apparent regard to other aspects of internal texture.

PROFUSE BASALTIC TEMPER

The ferromagnesian volcanic sands in sherds with profuse basaltic temper are moderately sorted assemblages of subangular to subrounded grains with a texture suggestive of alluvial origin. Unmistakable rounding of the edges of many grains indicates naturally occurring sand, rather than artificially crushed aggregate, and local ravine streams may have provided the sources of the temper. As would be expected for such a setting, lithic fragments are generally but not uniformly larger than mineral grains. Abundance of subangular silty basalt detritus within the clayey paste in which the temper sand is imbedded suggests that potters collected naturally tempered sandy clay. This circumstance may account for the superabundance of temper sand in proportions higher than typically encountered in Pacific Island sherds. Proportions of grain types in most sherds containing this alluvial temper are quite consistent (table 10.1): half pyroxene, a quarter lithic fragments, a fifth olivine, and a trace of opaque iron oxides. All microphenocrysts in lithic fragments are pyroxene and olivine. As the internal texture of lithic fragments is somewhat variable, being three-quarters "lathwork" in two sherds (1, 7) and two-thirds "slabwork" in four others (2, 5), collecting sites were evidently closely related but not identical. Nevertheless, the average temper composition (table 10.1) for the six sherds in which proportions of grain types are essentially the same is taken here to be the best estimate, petrologically speaking, of proportions of constituents for characteristic To'aga temper.

Table 10.1
Frequency Percentages of Ferromagnesian Mineral Grains[1] and Basaltic Volcanic Lithic Fragments (VRF) in Sherds Containing "Profuse Basaltic Temper"

Sherd	n	Py	Ol	Fe	VRF	Py(Py+Ol)
1	130	51	21	2	26	0.71
2	160	50	23	2	25	0.68
3	210	53	20	1	26	0.73
4	105	51	17	4	28	0.75
5	185	50	24	4	22	0.78
7	260	54	23	1	22	0.71
Ave		52	21	2	25	0.71
14		36	14	3	47	0.72

[1]Py, clinopyroxene; Ol, olivine; Fe, opaque iron oxides
Note: n=number of grains counted in each sherd and average (Ave) composition is calculated for sherds 1-5 plus 7 but not 14.

A seventh sherd (14) contains distinctly more lithic volcanic sand (table 10.1), although its pyroxene/olivine ratio is very close similar to that of the other sherds. Lithic fragments, mostly "lathwork," are also more irregular in shape and some are microvesicular. Curved re-entrants on some lithic fragments and the presence of a few grains of microvesicular brownish basaltic glass suggest a pyroclastic component lacking in the more characteristic six sherds whose tempers were probably derived entirely from bedrock lava sources.

SPARSE BASALTIC TEMPER

The ferromagnesian volcanic sands in sherds with sparse basaltic temper are well sorted aggregates of subrounded grains with a texture suggestive of beach origin. The lack of finer grained grit within the clayey paste suggests that potters added artificial temper to clay bodies. Dark angular blotches within the clayey paste are probably ghosts of broken pottery fragments also added as part of the tempering process. Although recognition of this grog constituent is equivocal in some sherds owing to indistinct outlines of the pottery fragments, its presence may account for the low overall proportion of volcanic sand, which amounts alone to much sparser temper than typically encountered in Pacific Island sherds. Frequency percentages of grain types are highly variable for different sherds (table 10.2), but so few grains are present in each sherd (average of only 20 per sherd in 10 of the sherds) that the statistical significance of individual counts is questionable. Consequently, all grains (250 total) were summed from all sherds counted to yield net frequency percentages, but net and average temper compositions are almost identical (table 10.2). The fact that both measures of bulk composition are similar to values for the single sherd (22) containing the most grains (60) gives confidence that either measure is a valid estimate of the overall temper composition. The sparse basaltic temper, probably beach sand, is less pyroxenic and more lithic than the average composition of the dominant alluvial variant of the profuse basaltic temper, but grain proportions closely resemble those in the more lithic variant of alluvial sand. In general, differences are not great enough to suggest wholly different provenance except for the contrast between stream and beach collecting sites. Proportions of lithic grain types are quite variable from sherd to sherd, but all three types are present in subequal amounts within the suite of twelve sherds as a whole. The net pyroxene/olivine ratio (0.63) is only slightly lower than in the alluvial sands (0.72), and may have been reduced marginally by preferential cleaving of pyroxene grains and winnowing of resulting cleavage fragments during prolonged reworking in a beach environment.

Table 10.2
Frequency Percentages of Ferromagnesian Mineral Grains and Basaltic Volcanic Lithic Fragments (VRF) in Sherds Containing "Sparse Basaltic Temper"

Sherd	n	Py	Ol	Fe	VRF
6	20	5	10	5	80
10	10	40	20	10	20
16	15	47	33	7	13
19	30	33	13	4	50
20	10	30	20	10	40
21	10	40	20	10	30
22	60	42	20	2	36
23	25	32	20	8	40
27	30	40	40	3	17
28	20	25	5	5	55
29	20	25	15	5	55
Net	250[1]	34	20	4	42
Ave		33	20	6	41

[1]Summation of n for 11 sherds listed.
Note: n=number of grains counted in each sherd (note that net and average compositions are essentially the same). Sherd 13 too weatherd to allow accurate count.

FELDSPATHIC BASALTIC TEMPER

The volcanic sand in sherds (15, 17, 18) containing feldspathic basaltic temper essentially lacks ferromagnesian mineral grains (table 10.3), and nearly all microphenocrysts in lithic fragments are plagioclase rather than pyroxene or olivine. One olivine grain is present, however, in one sherd (18), and one olivine microphenocryst is present in another (15). Lithic fragments are consistently larger than separate plagioclase mineral grains, although the two are present in about the same frequency (table 10.3), and the sand overall is only moderately sorted. Most lithic fragments are "tachylitic," many have smoothly curved re-entrants typical of tephra clasts, and some are microvesicular. The textural features of the sand jointly suggest that scoriaceous basaltic ash, possibly reworked locally, was added as artificial temper to the clay body by potters having some selective aim in using such a tempering material. The feldspathic basaltic temper shows no compositional overlap with the ferromagnesian basaltic tempers, but the geographic separation of their respective sources need not have been great. As if to underscore that point, one sherd (9) contains well-sorted and subrounded temper, probably a beach sand, that apparently represents a mixture of feldspathic and ferromagnesian volcanic sands. This anomalous sherd has an apparently sparse temper (~15% of body) but also includes a few fragments of broken pottery as part of its overall temper component.

MIXED TEMPER SAND

The volcanic sands in sherds containing an admixture of reef-derived calcareous grains (15-75 percent) are highly variable in mineralogical composition (table 10.4). Although all are dominantly ferromagnesian volcanic sands, nearly half contain feldspathic components as well. Coupled with the presence of the calcareous grains, the good sorting and rounding of the sands is diagnostic of coastal origin on beaches where mixing of detritus from multiple sources is to be expected. Proportions of temper sand vary from 10-25 percent (8, 11, 12, 24)

Table 10.3
Frequency Percentages of Plagioclase Feldspar (Pl) and Opaque Iron Oxide (Fe) Mineral Grains and Basaltic Volcanic Lithics Fragments (VRF) in Sherds Containing "Feldspathic Basaltic Temper"

Sherd	n	Pl	Fe	VRF	Py	Ol
15	60	43	8	49	-	-
17	35	50	6	44	-	-
18	125	56	4	40	-	-
Ave		50	6	44	-	-
9	60	18	7	59	13	3

Note: n=number of grains counted in each sherd and average (Ave) composition is calculated for sherds 15 plus 17-18 but not 9 (Py and Ol are clinopyroxene and olivine mineral grains in sherd 9).

Table 10.4
Frequency Percentages of Calcareous Grains (calc), Silicate-Oxide Mineral Grains, and Lithic Fragments for Sherds Containing "Mixed Temper Sand"

Sherd	Calc	n	Py	Ol	Fe	Pl	VRF
8	13	65	32	32	3	-	33
11	22	35	14	7	7	-	72
12	20	12	33	17	25	-	25
24	15	30	27	23	-	-	50
25	44	70	21	17	1	1	60
26	18	160	22	18	1	5	54
30	77	60	39	14	2	20	25

Note: n=number of non-calcareous grains counted in each sherd (percentages reported sum to 100 exclusive of calcareous grains)

to 40-60 percent (25, 26, 30), the "tachylitic" variety of lithic fragments form about half the lithic population, and the overall pyroxene/olivine ratio (~0.60) is similar to that in the other sherds thought to contain beach sand temper. Computation of an average or net composition for the sherds containing mixed sand temper would be meaningless, given their inherent compositional variability, but their volcanic sands fit broadly within the spectrum of temper types present in other sherds. Sherds containing only sparse mixed temper sand also contain fragments of broken pottery in uncertain amounts.

DISCUSSION: TEMPER COMPARISONS

Although each of the To'aga temper types has clear distinguishing characteristics, compositional links argue that they form a related temper suite that is presumably indigenous to Manu'a. The two ferromagnesian basaltic tempers have contrasting textures that reflect different sedimentological origins such as stream and beach sands, but the same grain types are present in both in slightly different proportions. The admixture of similar ferromagnesian constituents in one of the sherds containing feldspathic basaltic temper suggests that bedrock sources for the ferromagnesian and feldspathic volcanic sands exist not far apart. This inference is strengthened by the observation that mixed beach sands containing calcareous grains contain a varied spectrum of ferromagnesian and feldspathic constituents.

Prehistoric sherds examined previously from 'Upolu (Dickinson 1969, 1974, 1976) contain generally similar basaltic temper sands composed of the same basic grain types, but none of the 'Upolu tempers is identical in texture or composition to the To'aga tempers. Ferromagnesian basaltic tempers from 'Upolu commonly contain a higher proportion of lithic fragments, typically have a higher ratio of olivine to pyroxene, and generally contain a subordinate proportion of brownish basaltic glass particles not present in To'aga tempers. Moreover, 'Upolu sherds with abundant ferromagnesian tempers contain well-sorted coastal sands texturally unlike the stream sands evident in well tempered To'aga sherds. Feldspathic basaltic tempers from 'Upolu are broadly similar to their To'aga analogs, but internal textures of lithic fragments differ in being coarser grained in the 'Upolu sherds studied to date. Feldspathic trachytic tempers present in all available 'Upolu collections apparently have no counterparts at To'aga.

The generic resemblance of all Samoan temper types examined to date permits the strong inference that the tempers in To'aga sherds are indigenous to Samoa. On balance, there is no reason to suppose on petrographic evidence that any of the To'aga temper types were derived from sites elsewhere in Samoa. The fragments of broken pottery present in about half the To'aga sherds are not common constituents of Pacific Island wares, but do occur in sherds from the Ryukyu Islands, Palau, and the Nan Madol site on Ponape (Dickinson and Shutler 1979; Dickinson et al. 1990). Their presence at To'aga presumably reflects a common paucity of suitable local temper sand, rather than any close cultural relationship between the Caroline Islands region and Samoa.

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