

stonexus

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TROW AND HOLDEN TOOLS

Front cover: Gurness Broch, on the eastern coast of the Orkney mainland, an Iron Age tower around which a village grew. The lane leading to the imposing entryway, and the entryway itself, seem designed to impress visitors. Low-roofed cells flanking the opening are assumed to have housed guard-dogs.
photo: T L

Opposite left: The Writers' Museum, Edinburgh, dedicated to Scotland's noted men of letters: Robert Burns, Sir Walter Scott and Robert Louis Stevenson. Just off the Royal Mile leading to Edinburgh castle, this building, erected in 1622 and modified in the 18th century, exhibits the structural complexity and romantic expressionism that flourishes here and there in the generally conservative architecture of the city. The stonemasons whose responsibility it was to realize the plans for this structure must have welcomed the challenge.
photo: T L

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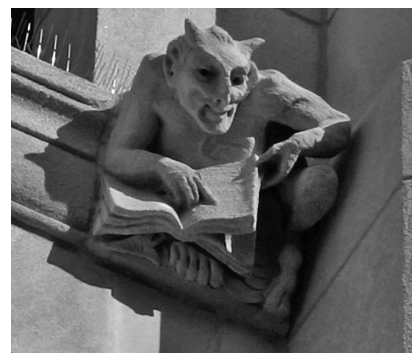
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stone (ston) n.

1. a. Concreted earthy or mineral matter; rock.
b. Such concreted matter of a particular type.
Often used in combination.
2. A small piece of rock.
3. Rock or piece of rock shaped or finished for a particular purpose, especially a piece of rock that is used in construction.

nex-us (nek' sas) n., pl. nexus or nex-us-es.

1. A means of connection; a link or tie.
2. A connected series or group.
3. The core or center.

mag-a-zine (mag-úh-zeen), n.

1. A periodical containing a collection of articles, stories, pictures, or other features



To new readers and new member/subscribers: welcome and *bon appetit*. We hope you enjoy this latest serving of stone-lore.

To member/subscribers of longer standing: your patience is appreciated. It's been a year since STONEXUS V came out and that's a long wait.

It was a busy year and a hectic one. Besides the demands of organizing the annual gathering last October and the distractions of earning a living, the structuring, deconstructing and restructuring of the Stone Foundation that has been going on since the Symposium absorbed considerable time, attention and energy. As it happened, the character of the organization and the future of the magazine were at stake. We're pleased to report that the situation has been resolved, that the Stone Foundation survives with its spirit intact and that STONEXUS will continue on its evolutionary path to being the best magazine it can be.

You may notice that there are two new departments, LANDSCAPE/HARDSCAPE and SCULPTURE, showcasing various aspects of those areas. Also, there are two other departments for which submissions are encouraged: T & T (Tips and Techniques) and I.M.H.O. (In My Humble Opinion). The titles are self-explanatory, and certainly there are individuals reading this who would do well to share some of their experience, savvy, ideas, opinions.

There was a good crop of PHOTOS-TO-THE-EDITOR, but not much MAIL—please, express yourselves. Space constraints (64 pages is the economic ideal) led to the deletion of the mail pages for this issue as well as several pages of photos and articles, original and reprinted, that accumulated. This material constitutes a head start on the next issue—and yes, there will be two issues produced this year.

Thanks to the contributors who made this issue what it is. Much appreciated are the photos sent



in by Timothy Smith, Bobby Watt, Juliet Golden, Robert Waller, and someone (or someplace?) known as Verdabbio. Fraser Muirhead made available some of the fine architectural photographs he has taken during his peregrinations around Europe; expect to see more of his work in the future. Others, several others, also sent in excellent photos but space was limited.

Ithamar Perath's tale of how an ingenious/labourious ploy saved a city is a gem. Dry stone enthusiast John Shaw Rimmington shared one of his most recent adventures. And out of the blue came a CD of scans from a Bill Gallagher, not even a member/subscriber (he is now). This antique manual on stereotomy or stone-cutting techniques will be of interest to many. Good on you, Bill. And thanks to whoever it was (?) who sent in the kinetic little dry stone walling poem by John Walker.

Also, neither last nor least, an expression of gratitude for our advertiser/benefactors, Trow and Holden Tools, Select Stone Inc, and Rhino Tools; and to SF member John Henry, the genial, stone-mad gentleman who financed the expedition to Scotland last summer which provided the photos in the TEKTONIKA Gallery feature. Such patronage is always welcome; as Brendan Behan said, "May the giving hand never falter." Lithophilanthropy of this sort could enable future travels along The Old Stone Road—and future color in these pages.

Until now, STONEXUS Magazine has been an in-house publication, distributed only to Stone Foundation members. Early this year a major policy decision was made—to make it available to the general public. Beginning with this issue STONEXUS will be displayed for sale at some stone supplier premises and selected bookstores. Starting in 2007 there will be several options available. One may buy single issues, become a subscriber or join the Stone Foundation, the magazine being one of the entitlements of membership.

This should result in more readers for the magazine and, eventually, more members of the Stone Foundation community.

You can help: If there is a stone supplier or book store in your area that would be a good place to display the magazine for sale, send us the name and contact information, along with a contact person if possible. You might even show them one of your copies of the magazine. Please assist us in this, thanks.

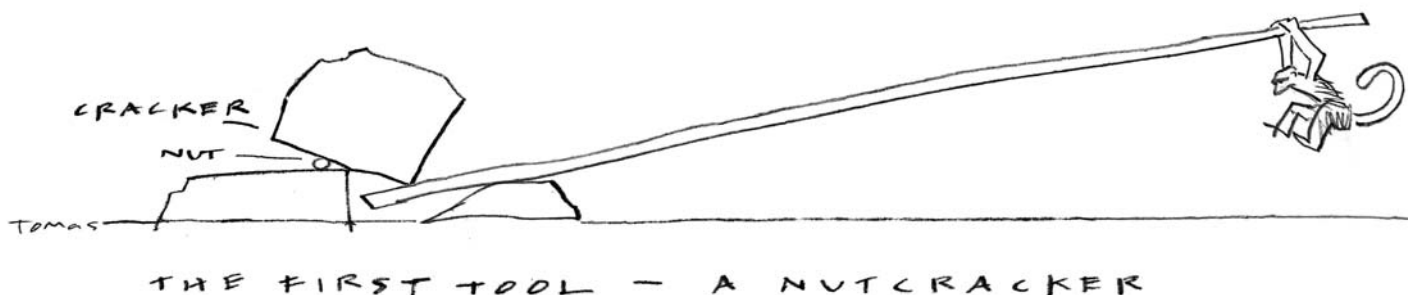
Keep well and keep up the good work.

Editorially yours,

Tomas

Tomas Lipps

P.S. On the visible sides of the worktable in the photo above are two of four attributes considered important to the practice of the craft of stonemasonry, Patience and Fortitude. Readers are invited to guess what the other two might be. The first one to do so will receive free membership in 2007 and a T-shirt of his or her choosing. All of the suggestions will be printed in the next issue.





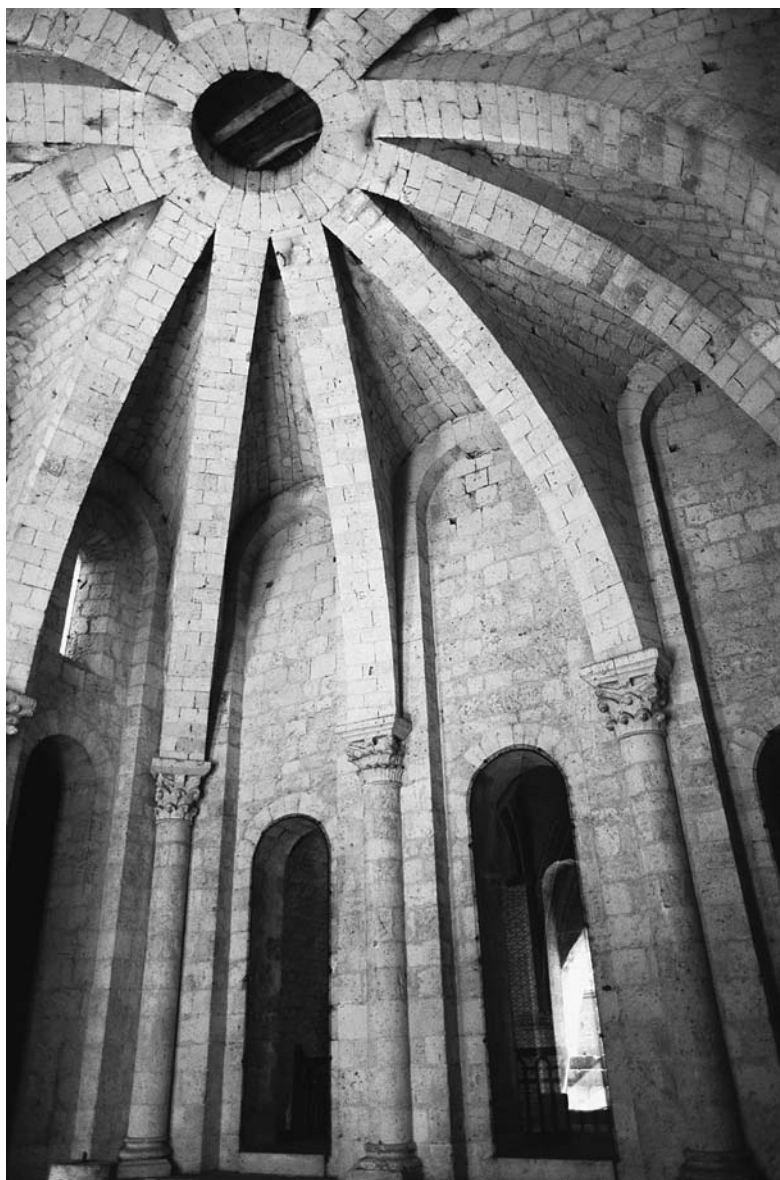
TIMOTHY SMITH, Matera, Italy

PHOTOS TO THE EDITOR



Balfour Castle, Shapinsay Island, Orkney

FRASER MUIRHEAD, The Romanesque Abbey of St. Pierre at Moissac



VERDABBIO



BOBBY WATT *Inukshuk*, Canadian Embassy, Tokyo, Japan





ROBERT WALLER

THE LION MONUMENT

Just northeast of Lowenplatz is one of the highlights of Luzern, the terribly sad Lion Monument. This dying beast draped over his shield, with a broken spear sticking out of his flank, was hewn out of a cliff face in 1821 to commemorate the 700 Swiss mercenaries killed in Paris in 1792. On August 10 that year, French revolutionaries stormed the royal palace, the Tuileries; in the face of the mob, the Swiss palace guards were ordered to lay down their arms by Louis XVI and were subsequently massacred. This would be a movingly tranquil spot, with its foliage and gently rippling pool in front, were it not for the fact that it's the single most toured place in the entire city.

from *The Rough Guide to Switzerland*

ZIO BASILE

Our builder's wife's uncle Basile arrived this morning to get started on some traditional Pugliese dry stone walling. Aged 85, Zio Basile clocked in at 7:00 am this morning and is still at it, although he's now removed his waistcoat!

He plans to chop up all of these big blocks (with an axe and hammer) into smaller ones, then build the wall(s). At lunch-time, I was just in time to stop him clambering over the 2 metre garden barrier cos he couldn't figure out how to open the gate!

JANE
(the friend of Juliet Golden who forwarded this to us)



Lace wall, Shetland mainland, Scotland

TL

steps landing costumed parapet 2'-6"

THE ART OF THE STONEMASON

by Ian Cramb

sheet
2' or 50mm thick
springing line
1st stage
built to form, save a arch, do not infill with concrete or loose rubble.
foundations and all below ground level, allow 3' or 75mm scarcement, section through D
laggins L center frame?
savers a lime grout each level.
details for 'sow' or 'hunch' back bridge.
cope
3'-0" or 914mm to 8'-0" or 24384mm max.
butt butt

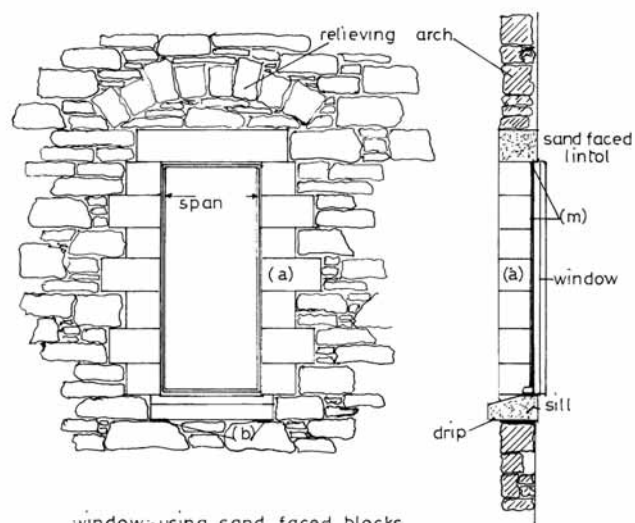
Drawing on five generations of family tradition as stonemasons in his native Scotland, Ian Cramb created this masterful work to pass on his knowledge and experience to craftsmen who wish to learn the ancient, but still necessary, principles of the stonemason's art. Since original publication by Betterway Books in 1992, this book has established itself as an essential learning tool for masons doing new construction and also those engaged in restoration of historic stone structures.

The Art of the Stonemason is profusely illustrated with the author's meticulous line drawings and photographs.

Ian Cramb began his apprenticeship at the age of 14 in Dunblane, Scotland. Surrounded by large estates, farm buildings, a ruined 13th century bishop's palace, two large 15th century castles, a Gothic cathedral, and numerous other stone buildings, Dunblane was an apprentice stonemason's paradise. In 1957 Mr. Cramb took over as master stonemason on the restoration of the monastic buildings around the abbey on Iona. He rebuilt the cloisters, restored St. Michael's Chapel, and also restored St. Oran's Chapel in the Cemetery of Kings, built in 1075. In 1959 Mr. Cramb moved to the US where he set stone and marble on the Capitol building, and then he acted as stone and marble mason for the Raeburn Building and World Bank Building in Washington, DC. He now lives in Bangor, Pennsylvania.

Out of print for years (copies were going for over a hundred dollars!) *The Art of the Stonemason* has been reprinted by Alan C. Hood & Co., Publishers. Happily, we are able to offer this book to Stone Foundation members at a 20% percent discount, for \$20, rather than the list price of \$25—plus \$2 postage. Send a check for \$22 to the Stone Foundation, 116 Lovato Lane, Santa Fe, NM 87505.

Figure 20

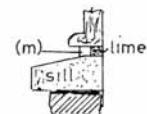


window:- using sand faced blocks, instead of dressed stone quoins (a)

relieving arch required if span is
over 3'-0"

oil-sand mastic pointing between
wood and stone (m)

sill-mortar at ends only. (b)



THE STONE CARVER'S IMAGINATION

(4 of 9 pages)

by Tadeusz Włodarczak and Juliet Golden

photos: Juliet Golden



Stone carver green man and his trusty tools: Is this a self-portrait?

IN THE SCOPE OF THE PYRAMIDS,

Mt. Rushmore, Stonehenge or even Michelangelo's *Pieta*, green men are incidents and details. But for me, these small anti-masterpieces scattered around the world come the closest to connecting us with our individual brother stonemason at work centuries ago building the temples, cathedrals, administrative buildings and even tombs revered today as classics of ancient and not so ancient architecture. Green men, or more generically mascarons, give us insight into the nature of architecture, but also the nature of the stonemason's job and the artistic license he employed at work.

I refer to them as anti-masterpieces because at most green men denote "flaunty ornamentation" dwarfed in the contexts of some monumental construction. These evocative pieces of a human scale are sort of free form improvisations; something like a cadenza in classical concerto, a moment when the orchestra stops playing and the soloist is set free from the strictures of the composition to invent music in a fit of creative expression without a strict, regular beat.

Traditionally, green men appear as ornaments at crucial points in a building: in brackets, roof bosses, capitals, column bases, etc. They proved useful as a motif because they were incredibly adaptable when employed to cover up "blemishes" in structures, such as at the intersection of ribs, groins, beams or at key points in a flying buttress. It was at these points in a structure that a stonemason

could "let it rip." At their best, green men are expressions of individual carvers' imaginations and the incarnations of their fears and hopes; their deities and demons. In green men we see what made the carver laugh and what made him cower. In the context of an edifice as a whole, green man became either visible focal points commanding attention or they could be hidden way, like a small witty "bonus." Regardless, these stones pique the onlooker's curiosity, inviting them to stop and wonder.

In contrast to the generic mascarons, which is the complete or partial representation of the human face or head, the green man (and very rarely, the green woman) is a face composed of, or peering out from foliage. The origins of the green man can be found in Roman art starting in the second half of the first century AD, according to Kathleen Basford in her seminal work *The Green Man*, published for the first time in 1978. She writes that some even described the motif as a male medusa. But these ancient works were manifestations of a pantheon of Roman gods. For me, the green men we revere today came out of the vast forests of northern Europe and they represent the taming of the fears that fertilized human imagination.

In Central Europe at least, the nineteenth century witnessed a resurgence in the popularity of the green men and their seculariza-



tion. Their ubiquity and the vast diversity of forms and styles reflect not only a fascination with the ancient world, but also a belief in the power of science and progress. Green men suddenly take on attributes of the ancient god's like Hermes, or gaze out from façades with the frozen theatrical expressions of Greek thespians. But despite their classic motifs, these are "greenhouse" green men, very much grounded in the industrial revolution. Their leaves are exotic, and architects and artists alike seemed to have reached for inspiration from voyages around the world or trips to the botanical gardens.

Depending on the geographic location and specific building

traditions, green men can be anything from profoundly beautiful to down right ugly and disturbing. Sometimes they smile benevolently, but most of the time they glare down at us in a threatening, menacing manner.

The best green men are carved in a "laid back" sort of way, but they exude life. They don't have to have faces, in the strictest of senses, but they have facial expressions. The leaves can be arranged so that the green man smiles; and the best smile is a secretive one that fits any occasion. The more enigmatic and ambiguous the expression, the more appealing the piece will be.



The creator of this green man must have been influenced by the Italian painter Archimboldo.



Lesna zoo

Unusual for Central Europe is this late-renaissance green man with the plant sprouting from his mouth.



This green man on the facade of the Exchange Building serves as a springing stone for two arches. (Wroclaw, Poland)



A strangely Oriental green man



This is one of several green men that flank the statue of Holy Mary on the main entrance of the cathedral in Wrocław, Poland.



Green man squashed under a flying buttress:
The pressure of his job made this green man lose most of his leaves and caused his eyes to bulge.

AT STONework SYMPOSIUM 2005,



among the most popular presenters were a pair of accomplished sculptors from Japan, Kate Thomson, a native of Edinburgh, Scotland, and her husband, Hironori Katagiri from Sendai in the north of Japan. They frequently participate in international sculpture symposia and are known for large-scale public art projects as well as the elegant work they have exhibited in the gallery milieu, both individual and group shows, principally in Japan. While they have each developed distinctive individual styles, the couple often works together on projects. Both Kata and Kate are Stone Foundation members.



Mt. Mukai Shiragami, H.K. grey granite



Under the Same Sky, K.T. Lebanese limestone





Day and Night,
H.K. basalt



What Dreams Come, K.T. black granite



Longing Home, H.K. basalt

EAST BY NORTHWEST

*Robert Murase's wetland retreat showcases
the sculptural use of stone.*

By JM Cava

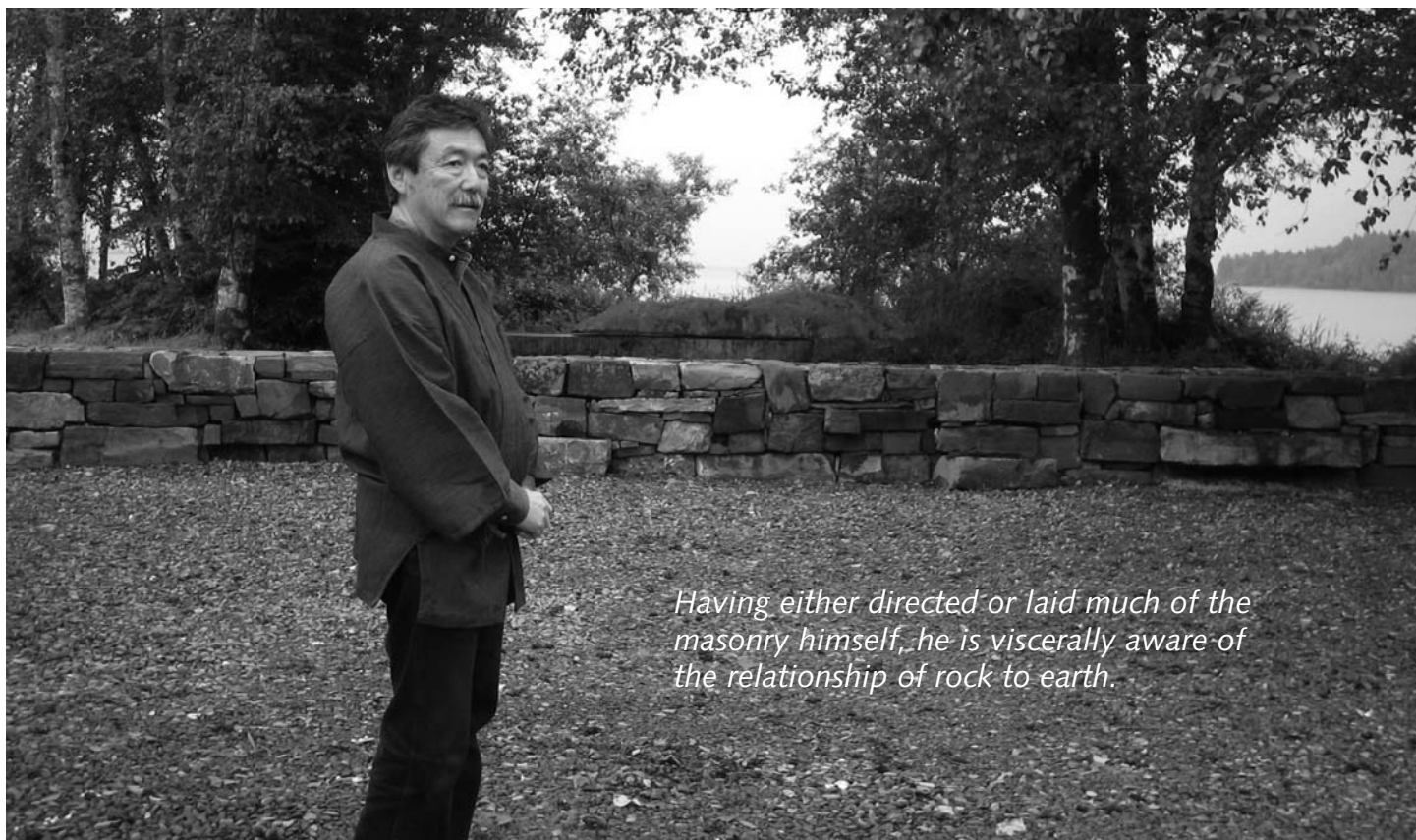
*"They say in Japan that the end interest of old men is stone—just stone,
natural stone, ready-made sculptures for the eyes of connoisseurs."*

—ISAMU NOGUCHI

On the Washington side of the Columbia River, about 20 miles east of the Pacific Ocean, is Gray's Bay; 100 acres of pristine tidal wetland named in 1792 for the American explorer Robert Gray. Thirteen years later almost to the day, Lewis and Clark rowed into the bay from the east, thinking they were seeing the "great Pacific Ocean which we been So long anxious to See...." Sheltering there from a Pacific storm from which "Several of our party were Sea Sick" and "...wet and disagreeable...." They nevertheless dined with local Indians on fresh salmon and remarked on the "great many swans, geese, ducks and other water fowls". Nearly unchanged since that visit, this ecosystem is a rare representation of

the Pacific Northwest coastal landscape from 1805, when Sitka spruce and shrub swamps extended from Oregon to Alaska, playing host to migrating ducks, coastal sea birds, bald eagles and geese.

Robert Murase, a landscape architect with offices in Portland and Seattle, was driving along the Oregon side of the Columbia River to a project on the coast when he decided to investigate the less traveled Washington side of the river and so stumbled upon a stunning five-acre parcel of land overlooking Lewis and Clark's sheltered wetland. After three years of negotiations, he purchased the property and soon began construction of the place he calls Santi-ya, combining "santi" a Sanskrit word for peace or tranquility, and "ya" a Japanese expression meaning place or house. For lack of a better term, Murase refers to this environment as a "retreat", for the building is neither beach house nor cabin and the land around it



*Having either directed or laid much of the
masonry himself, he is viscerally aware of
the relationship of rock to earth.*



defies any real definition as either garden or traditional landscape. It is, instead, a set of inhabitable constructions and places, changing and evolving over time, as Murase and his son Scott—educated as an architect, but now primarily a sculptor—gradually design, plant, sculpt, teach and build.

An artist's best achievements often result from attempts to reconcile opposing forces, achieving something new in the process that transcends the boundaries of either one. Murase, a third generation Japanese-American, has used this cultural conflict to his advantage over the last 30 years, in landscape and more specifically toward stone and earth, to achieve just that. This cross-cultural modern/ancient synthesis, however, took time. It began with his Berkeley studies in landscape architecture around the time of the well-known San Francisco Museum of Modern Art Exhibit in 1958, featuring the masters of the new American landscape on the West Coast; among them, Lawrence Halprin, Garrett Eckbo, Thomas Church, James Rose and Robert Royston.

After short apprenticeships with both Halprin and Royston, Murase moved to Japan with his family in the late 1960's to more deeply explore the Japanese aspect of his heritage. He did this not just through the traditional genre of garden architecture, but through a cultural immersion in the ancient and spiritual arts of ceramics and the all-important tea ceremony, which after the 16th century, not only revolutionized all Japanese art forms—architecture, gardens, ceramics, textiles, painting—but more importantly what Okakura Kakuzo called, "the conduct of life"; promulgating the Zen idea that there is "greatness in the smallest incidents of life."

Equally influential was Murase's fortuitous meeting and subsequent friendship with the great Japanese-American artist, Isamu Noguchi. Murase often visited the sculptor at his studio on the island of Shikoku, where the older man encouraged Murase's studies of Japanese gardens, objects and culture. After building many gardens in Japan, Murase returned to America to teach at the University of Oregon. Fresh from his immersion in Buddhism and the art of tea, he was something of an enigma to American students. "We didn't quite know what to make of him," recalls Kim Ahern, a landscape architect in Boston who studied under Murase. "He was marvelous to work with in studio, but several students were confused—they had gotten used to the typical American college classroom where the teacher was more of an entertainer; Bob was the opposite—quiet, but so intense and focused on your work...in the end he was the best teacher I encountered."

At Santi-ya, the synthesis of art and landscape is commingled with American and Japanese traditional attitudes toward space and particularly, toward stone. It is primarily in the sculpting and placing of stone that Murase's practice has evolved and here, free to respond to his intuition, it reaches the sublime. Shakespeare said there are sermons to be found in stones, and Murase is determined to help them find their voices. Having either directed or laid much of the masonry himself, he is viscerally aware of the relationship of rock to earth. Noguchi might have been talking about the stones at Santi-ya when he said, "Every rock gains enormous weight, and that is why the whole garden may be said to be a sculpture, whose roots are joined way below. I like to think of gardens as sculpturing of space..."

CIRCLES OF STONE



The standing stones of the British Isles, though silent, speak of the vision and determination of the ancient folk who quarried, transported and erected them. These were temples, a constellation of spiritual centers that continue to radiate an enigmatic power across the ages. Their mute, massive presence arouses admiration for the generative impulse, the effort and skill involved in their creation.

Two of the most notable examples are to be found in the Hebrides and Orkney Islands. Callanish, on the Isle of Lewis in the Outer Hebrides, pictured above and on the next page, is a remarkably concentrated, roughly cruciform grouping of gneiss monoliths. The uncompleted north/south, east/west avenues converge upon (or radiate from) two stone circles that are not concentric. The tallest, most imposing monolith is one of those comprising the inner ring and it stands at the approximate center of the wider ring. At its foot is a tomb chamber, presumed to be that of a later culture.

Though the axes of the crossing lanes do not truly align with the cardinal directions and the significant astronomical correspondences inferred by archaeologists are dubious, Callanish, centered on its rocky ridge at the base of a wide peninsula, seems a hallowed precinct.

Ceann Hulavig, right, is one of three other stone circles within walking distance of Callanish. Five quite large boulders stand in a relatively tight circle. The fungus springing from the cow dropping in the foreground is *psilocybe semilanceata*, the so-called “magic mushroom”. It grew here when the pastoral folk that inhabited the island raised these stones and it might have been a source of inspiration.





BRODGAR

The Ring of Brodgar is located in the interior of the Orkney mainland. It stands on a small isthmus between two bodies of water, the Loch of Stenness, and the Loch of Harray. As with more contemporary temples, in the world of stone circles stylistic distinctions abound and Brodgar is as expansive as the Callanish assembly is compact. 340 feet in diameter, it was originally composed of sixty some stones. Of these, 27 remain as well as the stumps of 9 others.

Even more impressive than the standing stones is the surrounding ditch that was cut into the bedrock just outside the stones, isolating the circular plane—what archaeologists call a henge, a sacred precinct—on which the stones stood. Some of the stones were quarried from the ditch itself; others are believed to have come from a hill 7.5 miles away.

This ditch, approximately 10 feet deep and 16 wide was excavated with the only tools available at the time: stone and deer antlers. Imagine it, 13,000 tons of stone. Access across the ditch to the henge was achieved by two causeways, at the northwest and the southeast.



Brodgar, looking northwest

STENNESS

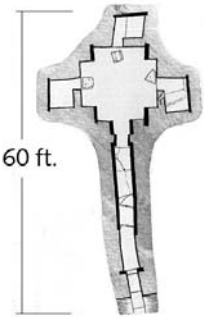
A mere mile to the southeast of Brodgar and connected by a narrow strip of land between the two bodies of water is, or was, another, smaller, and perhaps older, circle of a dozen or so standing stones, four of which remain—the Ring of Stenness. The proximity of these two entities implies a relationship that will forever elude knowing,

Compared to Brodgar, the Stenness circle is of much smaller diameter although some of the stones are taller. Within it there is an arrangement of three other stones, two standing, one recumbent. Looking over the recumbent stone between the two standing stones, centered in view one sees Maes Howe. (It is not known if this is the original placement of the stones and the mound has a much lower profile now than when it was built.)



MAES HOWE

This Neolithic chambered cairn is said to date from 2500-3000 BC, just a few centuries after Skara Brae. And, as at Skara, the material available had an influence on the design of the structure and the quality of the workmanship. The main chamber is about 15 feet square in plan and 20 feet tall; large blocks of the local sandstone weighing 10, 20, as much as 30 tons were skillfully assembled. A rectangular footprint 15 feet square was narrowed by corbelling in successive courses until the space could be covered with a single stone. Then, like similar tombs built in the Aegean and Crimean areas more than a millennium later, they were covered with a layer of clay and earth to form a mound much taller in silhouette than what we see here. The axis of the long passageway (extended at some point in time) runs from the chamber to the southwest, indicating some interest in the sunset around the time of the winter solstice. Note the buttresses at the inside corners; this is a master work. Evidently it slumbered forgotten in the landscape for more than two thousand years until Vikings broke into it.



Cameras are not allowed inside Maes Howe; shown here is a drawing from 1861 by A. Gibb and a plan view of unknown provenance.



SKARA BRAE

OVER FIVE THOUSAND YEARS AGO, a band of agriculturist/fisher folk took up residence at a place a short distance from the sea on the northwestern coast of the Orkney mainland. The stone peculiar to this locale may have attracted them; at the very least it facilitated and probably inspired the construction of their habitat.

The *Old Red Sandstone Igneous*, as it is known in contemporary geology, is ideally suited to the purpose. The nature of the material here—its strength and the regularity of the slab, flagstone, sheet, and tablet forms that readily separate from the matrix—enabled the builders to articulate their domestic environments with relative ease, forming, in the process, a vernacular building style capable of considerable sophistication. Skill and imagination are evident in the elemental features of this style: the ubiquitous central hearth, the clay-caulked cisterns, a drainage system, the voids in the masonry of the walls for display and storage, the “closet” beds and chairs and the covered passageways that linked the separate habitations.

The site hosted a series of occupying groups during a period of perhaps a thousand years before its ultimate abandonment. Then for four thousand years the settlement lay forgotten—and preserved—beneath a mound of sandy soil that accreted around the core of its existence. To 19th century Orcadians this mound was known as Skerrabra.



In 1850 a particularly fierce storm struck the coast and the sea, higher now and closer to the site than originally, stripping away the ages-old covering to reveal the presence of the ancient village. Early excavations, conducted by amateurs with more enthusiasm than discretion, later proved detrimental when in 1925 another storm damaged the structures from which the protective blanket had been removed. In building a seawall to protect the remainder of the site, more habitations were discovered; and a few years later, serious archaeological work commenced. The result is a well organized and cogently presented site that constitutes an x-ray view of Neolithic life.



The masonry in the photograph above is not the best example of Neolithic building skills. Note the several unchecked vertical joints that extend through several courses in the facing wall. These stones have been stacked, not woven together, as they had been elsewhere. The corner of the right end of the wall and the passageway leading to a neighboring habitation is, however, quite well built. This is most likely evidence of a reconstruction at some point in time by a different mason, perhaps during the modern reconstruction. If so, it would illustrate the ethical dilemma confronting the restoration mason: to effect an authentic reconstruction involves incorporating characteristic flaws in the work, perhaps the very flaws that necessitated the reconstruction. Archaeological authenticity sometimes requires such a suspension of one's own aesthetic and structural standards.

The appeal of this material to the constructivist nature, developed or latent, is demonstrated by the activity of this family on the beach just below the Skara Brae site.





THE BROCHS

ROUNDHOUSES, DUNS, BROCHS AND WHEELHOUSES

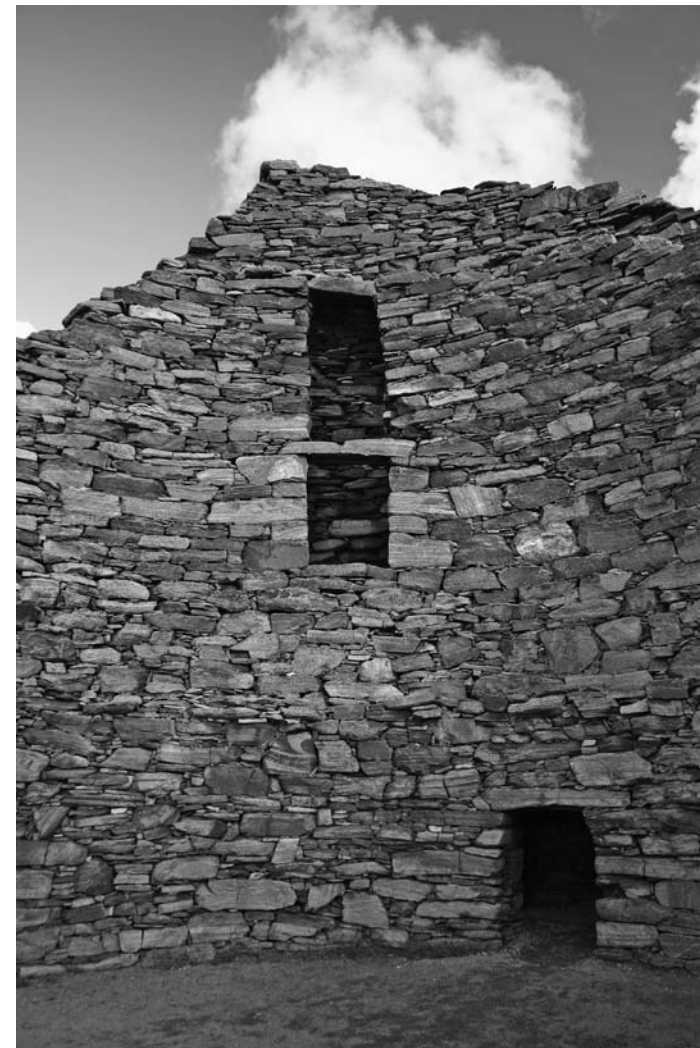
SCOTLAND, particularly the northern and western coast of the mainland and the Hebrides, Orkney and Shetland Islands is dotted with massive round stone structures, some of them tall enough to be classified as towers—the *brochs*. They were, archaeologists have come to agree, an indigenous architectural entity reflecting the needs, ingenuity and skills of the people who built them. Erected during the last part of the first millennium BC and the first century AD, the early Iron Age, they represent the high point of an evolving structural style peculiar to the British Isles.

During the Bronze Age, habitations on the northern and western regions of the European continent were predominantly rectangular in plan; across the channel they were circular. These ubiquitous Roundhouses, as they are known, had conical thatched roofs, the supporting poles resting *tipi* style on the ground or, particularly in upland Scotland, on low walls of stone and earth. Over time they grew in size, complexity and height; Roundhouses became more fortress-like, what are referred to today as *duns* and/or *brochs* (from *borg*, Norwegian for fort). In the Hebrides and Shetland Islands, however, the brochs were unprecedented, an imported concept. Bronze Age habitations there were thick-walled structures, irregular in plan, an amorphous central area with contiguous individual cells.

Archaeologists continue to debate whether the evolutionary step to the considerably more sophisticated *brochs* came about for defensive purposes (there is evidence of raiding by their close neighbors, the Irish Celts) or to assert social status, wealth and importance (the “castles” of local clan chieftains). There is no doubt, however, that it was achieved due to the emergence of a class of craftsmen whose skills are evident in the structures that survive. Similarities in design, technique and skill levels infer the involvement of master builders and teams of masons.

Variations abound but the elements are basically uniform. *Brochs* were round in plan and tapering in silhouette. Though squat, as towers go, they were an imposing feature, dominating the surrounding terrain. *Mousa Broch* in the Shetland islands, the only one that survives in a nearly original state (something it owes to its remote offshore location), is about 44 feet in height and 49 feet in diameter at base.

The dry-laid stone walls were immense, weighing as much as 2,000 tons and taking up fully half of the footprint of the structure. They consisted of an inner and outer wall, each 5 to 6 feet thick, separated by an intramural hollow 4 feet or so wide in which a staircase



Drawing by Alan Braby. From *Towers of the North* by Ian Armit.

gave access to the higher levels. (This hollow, which served to ventilate the wall and insulate the interior space, is something that survives in Scottish architecture to the present day in the form of cavity walls.) The stairway, galleries and the long lintels that bonded the inner and outer walls at intervals stabilized the structure and enabled the builders to carry the stone up to where it was to be placed.

There were no windows and only a single entry which could be barred from the inside. The inner surface had at least one *scarce-ment*, or ledge, created by a setback or extended corbels on which supports for a platform or upper floor could rest. How they were roofed is a matter of conjecture and considerable debate. Most scholars imagine some adaptation of the conical Roundhouse thatched roof (see artist's rendering).

The interior space contained a central hearth and cistern or, in some cases, a well or spring. The perimeter was often partitioned into “rooms,” particularly in the Orkneys where large thin slabs were available and lent themselves to this purpose. These interiors were modified considerably throughout a series of successive abandonments and re-occupations.





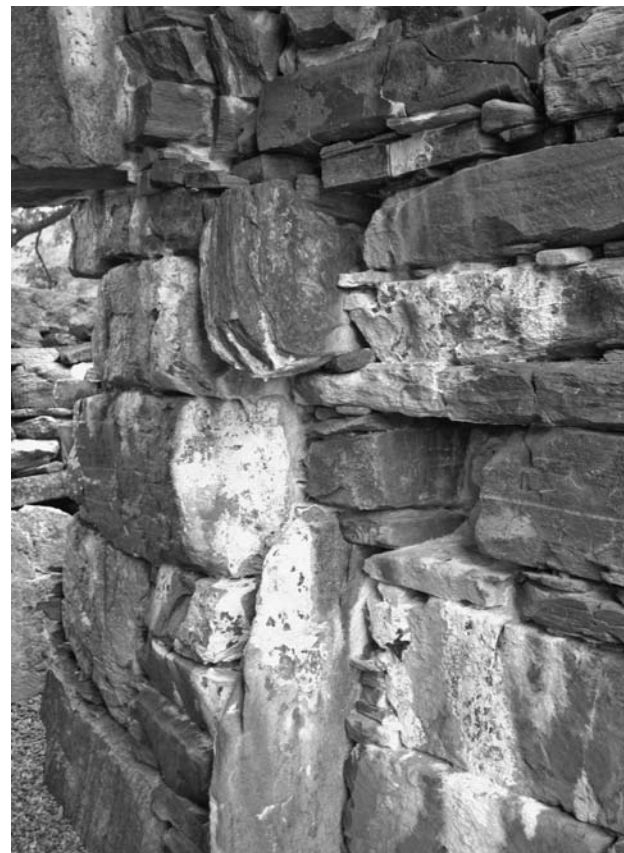
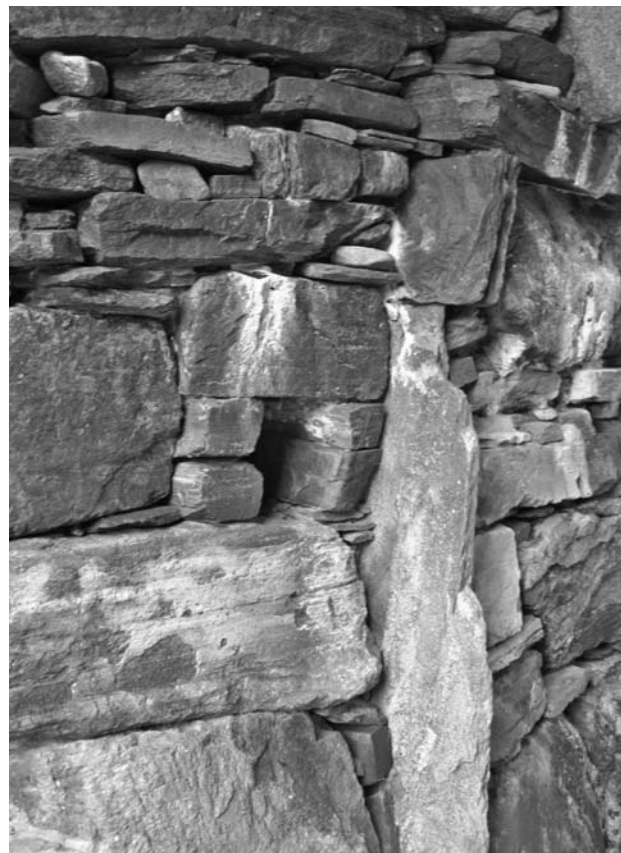
DUN TELVE

On the Scottish mainland just opposite Skye near the ferry landing at Glen Elg is Dun Telve, the finest example of the *broch*-builder's art on the Scottish mainland. It is one of a pair of towers built in unusual proximity. Much of the stone from Dun Troddan, the other *broch*, sited further inland and on the side of a hill, was removed for use in the construction of a barracks for English soldiers in 1722. Dun Telve must also have suffered pillaging, but enough remains of both *brochs* to understand their original proportions, the structural scheme and the skill of the masons. The photo on the top of the opposite page shows the intra-mural hollow between the interior and exterior walls and the row of openings which provided both ventilation and light to the galleries between the walls.

The photos at the bottom of the page were taken from the interior and show the door-jambs and bolt-holes on either side of the singular entryway.

BURROUGHSTON

On the right is the entry of the Broch of Burroughston on the small, green and fertile island of Shapinsay. A remarkable minor detail of the interior wall is shown below; the singular rounded rock, a geological anomaly, judiciously placed in this angular context is a subtle grace note, the record of a moment of artistic sensibility on the part of an ancient mason. It must have given him some satisfaction, though his mates quite possibly chided him for being cute.

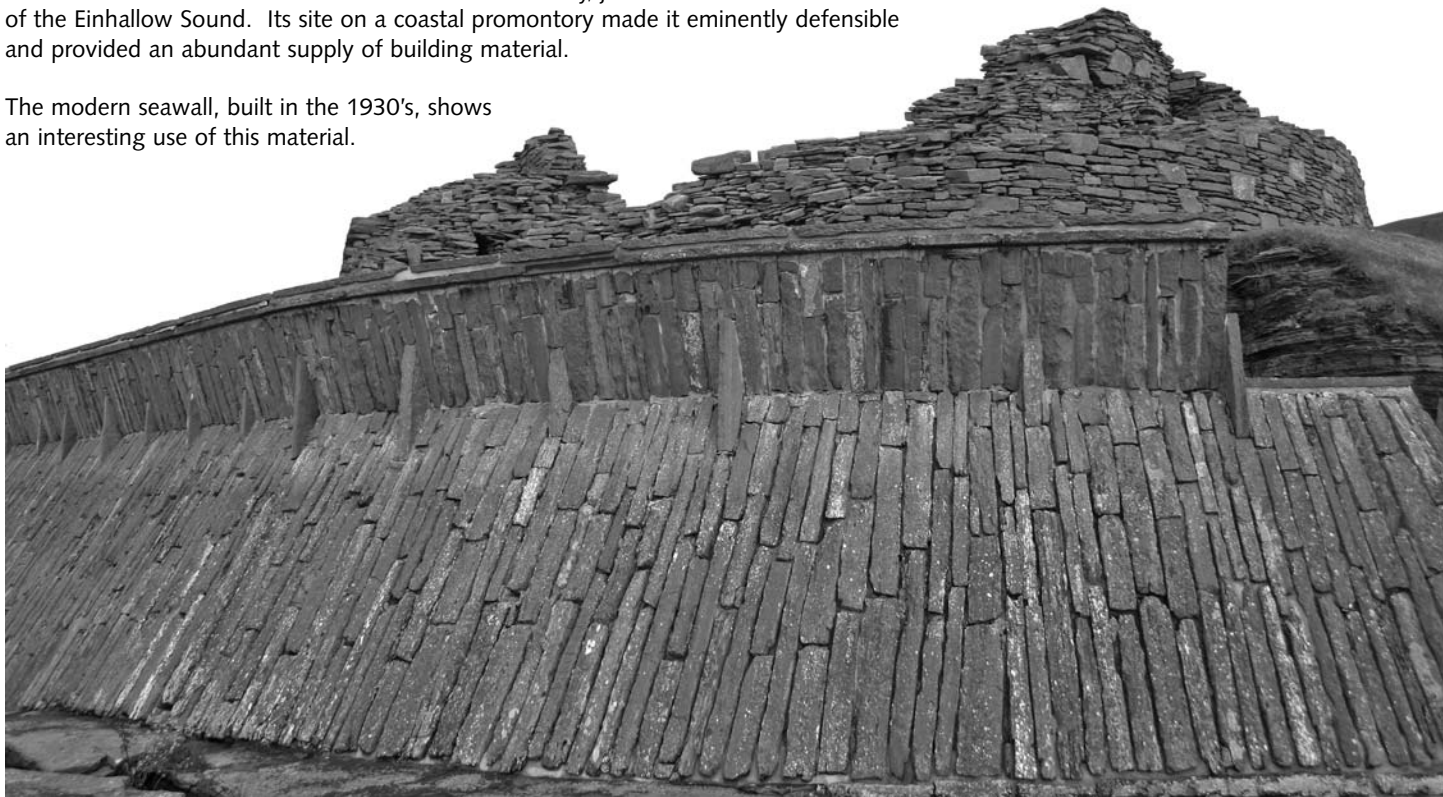




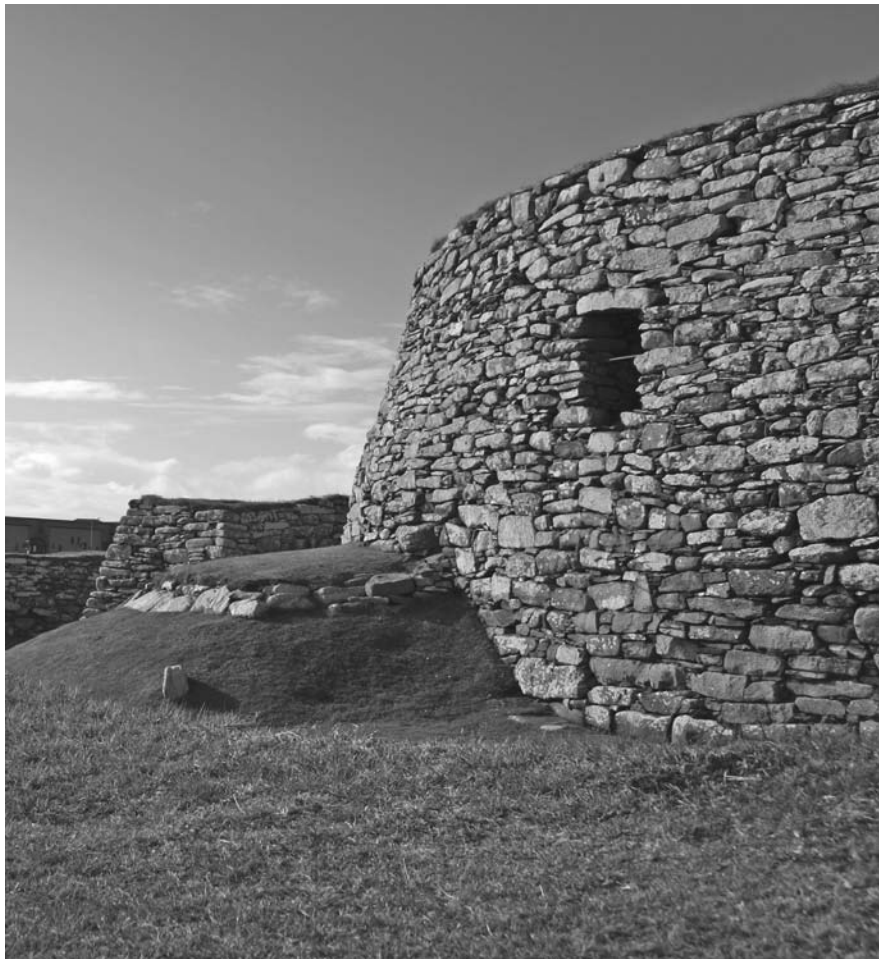
MIDHOWE

The two most impressive Orkney brochs are Gurness Broch (cover photo) on the northeastern coast of the Orkney mainland and Midhowe Broch on the southwestern coast of the island of Rousay, just across the turbulent waters of the Einhallow Sound. Its site on a coastal promontory made it eminently defensible and provided an abundant supply of building material.

The modern seawall, built in the 1930's, shows an interesting use of this material.



Brochs were often surrounded with ramparts, one or a series of walls fronted by ditches. Within these ramparts and outside the walls of some *brochs* a village of small irregularly formed habitations and enclosures for animals was built along a connecting lane (Gurness and Midhowe, shown here, are two examples). Another area of disagreement among archaeologists is whether the villages were constructed at the same time as the *brochs* or later, when the population had grown and/or the social organization had altered—and the need for defense (or status) had lessened and the towers, or at least their upper levels, were dismantled for building material.



CLICKIMIN

What began as a Bronze Age farmstead on an islet just off the southern shore of a small lake on the Shetland mainland evolved over successive occupations into an impressive *broch* settlement. Later, similar to the history of *broch* settlements in the Orkneys, the *broch* structure was reduced in height and the stone used in the construction of peripheral habitations. The quality of masonry here, both that of the ancients and that done during the reconstruction in the 1950's, is exceptionally high. The window in the photo at left, one of two on the lakeside wall, is unique in *broch* architecture and may indicate a lapse of historical authenticity during the reconstruction.

The structure in the photograph opposite is known as the "blockhouse". Built immediately inside the only entryway it doubtlessly had a defensive purpose and is said to predate the *broch* itself. The cell seen on the left side of the structure, had no access except from above—a dungeon?

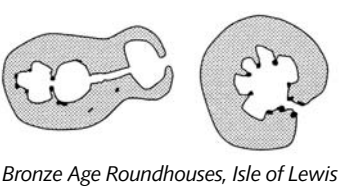
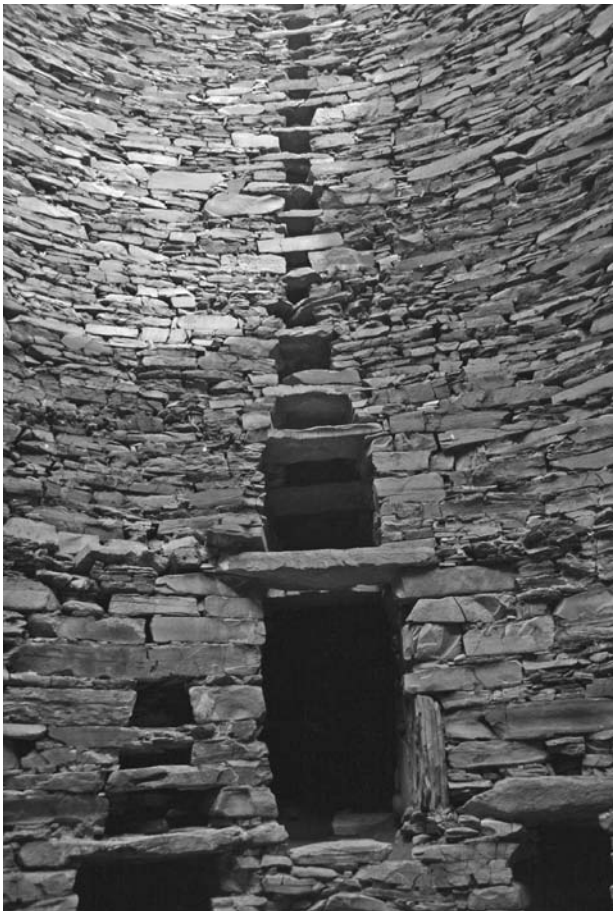
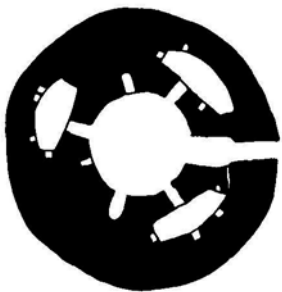




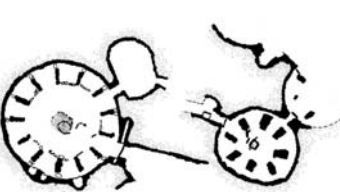
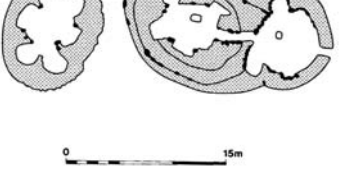
MOUSA

Mousa Broch is the only *broch* that survives reasonably intact. This has to do with its remote location on a small island off the eastern coast of the Shetland mainland. It is, or was, one of a pair; little remains of the *broch* on the other side of the sound between the island and the mainland. Mousa Broch is about 40 feet in height and 50 feet wide at base—the interior space is 20 feet in diameter. There is a stairwell in the intramural cavity that goes all the way to the top of the structure. The openings in the inner wall, shown in the photo at the right, presumably serve to ventilate the wall mass.

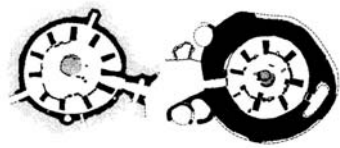
Like other *brochs*, Mousa fell into disuse in the first few centuries AD, but entered recorded history in the 12th century when it served as a refuge for a pair of Viking lovers. As told in the Orkneyinga Saga, a certain Erland abducted or eloped with Margaret, the mother of Earl Harold Madadson. Earl Harold pursued the couple and besieged the *broch* but the lovers were secure in their stoney keep, resisted the siege and later married.



Bronze Age Roundhouses, Isle of Lewis



Iron Age Wheelhouses, Shetland



Diagrams by Libby Mulqueeny.
From *Towers of the North*
by Ian Armit.

The *broch* building era terminated during the 1st Century AD. This happened earlier in the Hebrides and Shetlands than in Orkney. To meet the needs of a changing social structure and create discrete social and storage areas, the Orcadians continued to use the readily available thin sand-stone slabs as partitions. In the Hebrides and Shetlands, however, given the nature of the native stone, a distinctly different vernacular form of habitation evolved: Wheelhouses. These seem to be more sophisticated versions of the Bronze Age Roundhouses that preceded the *brochs* on those islands, the irregular contiguous “nodes” of the Roundhouse morphing into a ring of cells centered on the hearth, something quite unlike the Orcadian “apart-ments”.

Imposed onto the round footprint like the spokes of a wheel radiating from a hub (the open space around the central hearth) were regularly spaced radial walls defining a number of bays. These walls, thin at the base, were incrementally widened by corbelling to arch over the bays and, to an unknown extent, the central area. Archaeologists presume that this was roofed with the conventional conical thatched structure. But, speaking as a stonemason, couldn’t, wouldn’t, the builders have used their demonstrated skills and ingenuity to create a corbelled dome? With each corbelled ring in place, the structure is secure and the urge to continue is strong. These savvy craftsmen had intuited the form of a catenary arch and an arch, a segment of a dome, years for completion. Unlike a *broch*, the structure being thus covered could, with its low profile and ample base, absorb the lateral force exerted. The value of an *oculus*, a hole for smoke to exit and light to enter, would be apparent to those builders. Such a dome, though, would be the first part of the structure to disintegrate. Therefore, as no Wheelhouses have ever been discovered entire, there is no proof that this happened—or, that it didn’t.

However it was covered, this, the ultimate version of the Roundhouse, was a departure from the impracticalities of the *broch*. The low profile took it out of the wind and, nestled into the earth as it was, the Wheelhouse must have been a cosier place to live. Its less impressive exterior silhouette and more impressive interior space reflect a significant alteration in attitude and life style. The schematic and practical manner in which space is articulated is evidence of a structural intelligence at work. Architecturally, the *brochs* represent the high point of the Roundhouse lineage; the Wheelhouses were its crowning achievement. Ahead lay abandonment and, from two dissimilar sources, Roman and Viking, the advent of rectangularity. The age of the *broch* had passed, but it was an impressive moment in tectonic history. T L

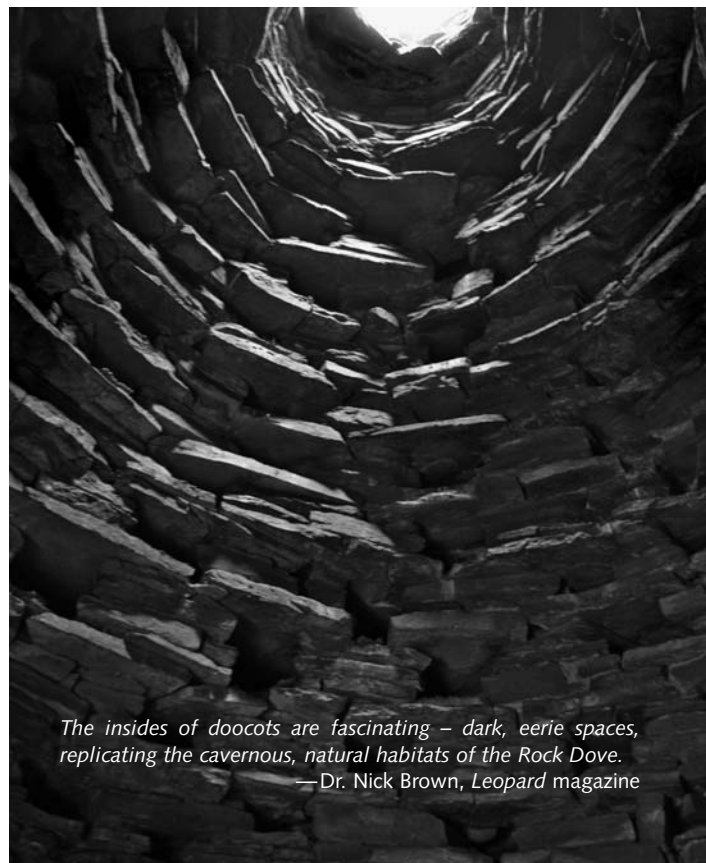


DOOCOTS

Dooocots or dovecotes were prominent features on the landed estates, abbeys and monasteries of Scotland well into the 18th century. Pigeons were valued for their meat and eggs, as well as for their droppings which made excellent fertilizer and were also used in the manufacture of gunpowder.

The beehive columbarium at right is on the Orkney mainland. The four string courses are to prevent rats from climbing the walls.

The Dishan Tower above is on the Balfour estate on Shapinsay Island in the Orkneys. Both doocots were built in the 17th Century. The columbarium is still in use, and can be visited; the Dishan tower was converted to a bathing house when Balfour Castle (see page 4) was built on the island at the middle of the 19th Century.



The insides of doocots are fascinating – dark, eerie spaces, replicating the cavernous, natural habitats of the Rock Dove.
—Dr. Nick Brown, *Leopard* magazine



KIRKWALL, ORKNEY

Just to the south of the St. Magnus Cathedral in Kirkwall stand the remains of two stately structures, the Bishop's and Earl's palaces. The former was built in the 12th century under Viking rule. Not long after the Norwegian King Haakon the Old died there a century later, Viking dominance ended and the palace fell into ruin.

The Earl's Palace was built in the early 1600's by the Stewart family who then exercised despotic rule over Orkney. Though one of the most elegant buildings of its kind, its association with the hated Stewarts led to continued neglect and ruin after they were deposed. It boasts several of the turrets springing from corbels that are so popular in Scottish architecture. The Great Hall, shown here, is said to have been one of the "finest state rooms of any castle in Scotland."



The arched opening of the fire-place is fifteen feet wide; note the way the voussoirs (arch stones) are shaped. The flare at the upper end serves to lock them into place. Still, it must have failed at some point, but the arch of discharge in the fabric of the wall above it performed as intended and held the weight of the upper masonry so that the arch could be replaced.





KIRBUSTER FARMSTEAD

*Peat-incense drifts towards the roof-vent,
much of it lingering, milder than acrid
coal-smoke, sweeter even than wood.*

*Like the stoic love
of the last family here, this fire
is at the centre of the room,
founded against a grand old stone.*

*Peat lies to hand in the neuk.
A settle and an Orkney chair tall-backed
and deeply curved like a half-barrel
drew children, wife and husband
into the sooty circle of love.*

*Soft flesh beneath this canapace,
far safer than any ancient turtle,
slept in a bed of three stone sides and roof
wrought from the very cliffs of Yesnaby.*

*Gales sigh against these walls.
"I'll huff and I'll puff,"
sighs the dog-tired wind.*

*The boot of God
could stamp on this and it would stand.*

—JAMES GRAHAM, SCOTLAND





BLACKHOUSES

Blackhouses were once the traditional habitations in the Highlands, the Hebrides and Ireland, and they were so named to distinguish them from the Whitehouses, which were more like contemporary homes—with windows, plastered walls in and out, and separate structures to house the animals—that began to supplant them toward the end of the 19th century.

Blackhouses were long, windowless, narrow buildings with compacted earth or flagstone floors, thick dry stone turf-packed walls and roofs thatched with reeds. The family, several generations of it, lived in one end of the house and in the other, separated by a partition, the animals. There was a central hearth, as at Skara Brae, but no chimney; the smoke was trusted to find its way out through the thatch, cleansing it of vermin in the process. The thatch was prized as fertilizer.

Shown here are two reconstructed Blackhouses—one of which functions as a museum—and the shells of several others. Often Blackhouses were constructed against other Blackhouses, sharing a common wall. On the right is a Whitehouse that was constructed against one end of a Blackhouse; at some later stage, the Blackhouse was removed.



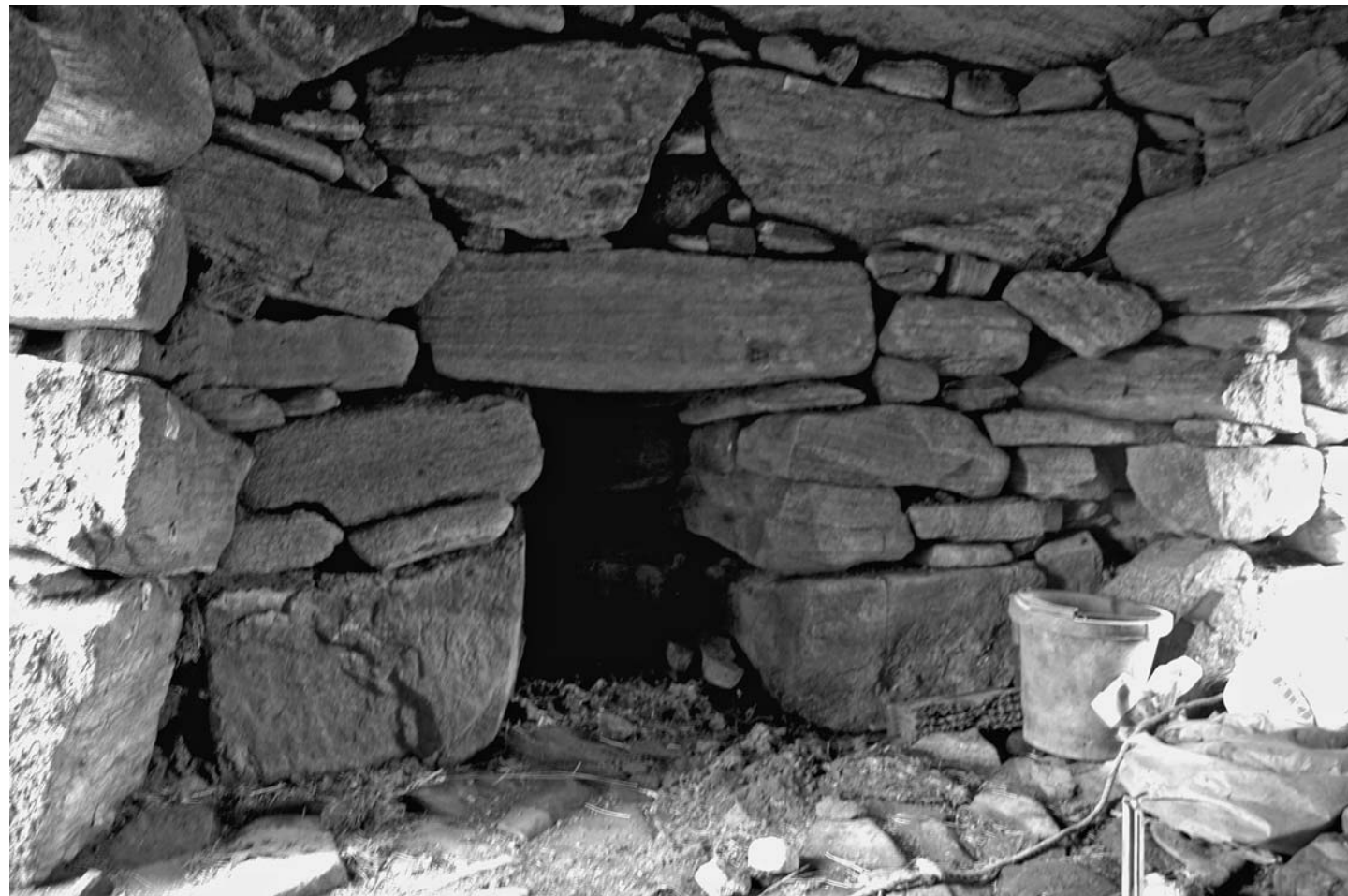


JAMES CRAWFORD

Stone Foundation member, stonemason and archaeologist James Crawford was our guide to the Isle of Lewis. On the left is a detail of the masonry in a World War One monument that he recently built with the local gneiss.

Below is a beehive structure known locally as a *both* or *bothy* that he has been engaged in excavating, investigating and restoring. Though it still served as a habitation at the end of the 19th century, pottery shards indicate that its origins may date to the Bronze Age. It was closed by corbelling as was common with such structures, but James reports an unusual feature—the corbel stones, some of which weigh more than a half-ton, were actually notched to achieve a better fit. The handsome archetypal hearth shown in the photograph seems to have been a mid-18th century improvement, converting what was originally a storage space to that purpose.

James' own home is pictured on the facing page. Here he has indulged his inclinations for artistic—and whimsical—stonework.





THE PIERCEMENT

by Ithamar Perath

TO SAVE A CITY

"It will have to go," said the smallest of the four men. He spoke with tired authority.

The other three were silent. They were standing on the easternmost rampart, squinting into the light of the fierce late-morning sun. The narrow valley below them stretched southward, its irrigation canals glistening among the lush green terraces. A desert breeze ruffled the dusty foliage of the great fig trees that hid the pool, beyond the foot of the wall.

"It will have to go," repeated the small man, "all of it." He took a breath. "We'll parch it to the last drop. We'll block up the channel so that nobody will know it was ever there. All this, trees, everything – " he made a slicing movement with his hand, the sun struck a spark from his seal ring, "we will cut. Not a stick will be left standing."

"If I may say so, Sir, it will starve the city," said the biggest of the other men. "We'll be dry carrion before he ever gets here. You'll undo the work of generations."

"He'll undo it faster than we could," said the small man, "and he'll be here before you gather your wits. He'll come down like a wolf on the fold. His cohorts are the fastest on earth. But we are going to dry them up, right here. D-R-Y. Drier than the hay on the roof there."

"If I may borrow another expression, we'll be feasting on our own turds first," spoke up a second man, "as that Assyrian bastard shouted at us from beyond the Upper Pool. And what are we supposed to drink?"

"We have the house cisterns," said the small man. "I'm having them enlarged. And the public cisterns up above there." He pointed back with his left thumb. "It's all in the Soft White Stone. Fast going. It should be ready by rain time."

The third man looked at him gravely. "So that's what you will do," he said slowly. "You will abandon your only spring of living water, and you will hew cisterns. L-e-a-k-y cisterns, for God's sake. You ought to know that that stuff is all cracked." His voice rose to an orator's pitch. "Two stupidities, not to speak of the third, which is royal folly at its grandest. How? I mean, how cracked can you get?"

The two others stared at him, shocked by the disrespect.

"Easy, Shaye," said the small man. "Whom do you think you are raving at? Getting up your voice? Your task is to discourage, not to berate." But he added a tolerant grin. The other man was not put out.

"So you have a plan," he said.

"Maybe, maybe not," said the small man. "But I know I have that spring, and I intend to keep it. Here. Under my city, guarded in everlasting rock. Rock as hard as my will and as red as my heart. I can also make big words, see?"

"Leave the big words to me, to yourself the big deeds," said the man addressed as Shaye. "Though this might be something too big for all of us." He had very black eyes which did not quite focus. "You must have something else that he does not have. And he seems to have everything."

"Yes, that's what he seems to think," said the small man. "You have seen that letter of his. Good strong phrasing. Kingly style. But I have you, and your phrasing is even better." Again he allowed a grin. "And I have our two friends here, whose wise muscles and muscular minds are better than your words, or mine. Shalon," he addressed the other man. "I want that spring down here to flow out on the other side, into the western valley. It can be done and you can do it. Tell me how."

"It already does," said the man called Shalon. He was bushy-browed and flat-voiced. "It flows along the Shiloah channel and rounds the corner down south, straight into the Old Pool. That's already inside the walls, pretty safe. We could put the open sections in closed masonry. They'll never get to it, at the foot of the wall."

"Not good enough," said the other man, who was the biggest, with tremendous stonecutter's hands. "They'll shoot us off the wall and get at it, on some dark night. Once they breach the casing, the water will be theirs. They will be taking baths while we drink the pool dry, and we've had it."

"Okay, we'll make it a tunnel," said Shalon. "The first section is already cut. They say Solomon did it. He stopped because it was in the Hard Red Stone all the way. But we have better iron than they had in those days. We'll get through."

"Too long, too risky, and too much time," said the small man. "We must go straight across. Under the city all the way. Starting at the spring, and due west-southwest. Tell me why not, Azbuq." "We can't start at the spring," said Azbuq. "We'd be working in water all the way. If we don't drown in one of the gushes, we'll choke to death, down there in the deep dark. There's dead air rises from that water. You wouldn't know that, Sir."

"Dragon's breath," added the other. "It blows off in open air. Down there it chokes you."

reprint

THE STONE DIARIES

by Carole Shields

HAVING KNOWN RAPTURE, my father, Cuyler Goodwill, could not live without it.

Once awakened, he was susceptible. It might have been poetry he embraced after the untimely death of his wife—or whisky or the bodies of other women—but instead, like many young working men of his time, he found God. In his case, God was waiting in the form of a rainbow east of the Quarry Road, not far from the plot where my mother lay buried.

This event occurred in the month of October, an early morning following a night of heavy rain.

In a cloth sack slung over his shoulder he carries an octagonal-shaped piece of limestone (about the size, say, of a cantaloupe) which he intends to place on his dead wife's grave. He climbs the fence at Taylor's Corners, taking a shortcut through a field of stubble, over the soaked uneven ground, when suddenly the sun bursts through, weakly at first, but quickly strengthening so that the heat reaches through the fibers of his gray cotton shirt. He looks up, and there it is: the rainbow.

Of course he has seen rainbows before in his life, always stopping, in the way of country people, to admire the show of watery iridescence. Rainbows, after all, do not occur so frequently in southern Manitoba that they go unremarked. "Look at that," someone or other is always sure to exclaim, pointing skyward, and then a wishful thought might rise up, a vague notion of impending good fortune or at least an alteration of mood.

At this time in his life Cuyler Goodwill had not yet begun his long immersion in Bible study, and could not have quoted, had you asked him, God's post-flood declaration to Noah: "I do set my bow in the cloud, and it shall be for a token of a Covenant between me and the earth."

At the same time, he is not by any means an ignorant or superstitious man (though limited in formal schooling), and he understands the general principles of rainbows, that the prismatic effect is caused by the refraction, reflection, and dispersion of light through droplets of water. He understands, too, the evanescence of the phenomenon, its insubstantiality—he is, after all, a man who works with stone, with hard edges and verifiable volume. The arc of a rainbow cannot be touched; its dimensions are not measurable, and its colors fade even as they are apprehended. There is a belief, for that matter, widely subscribed to by simple people, that a rainbow cannot be photographed, that its fugitive and transitory composition resists the piercing lens and the final proof of chemically treated paper.

But the rainbow that appears before my father on that October morning in 1905, a mere three months after his wife's demise, is different, its colors more vibrantly distinct, its shape as insistent as a child's crayon drawing. This rainbow seems made of glass or a kind of translucent marble, material that is hard, purposeful, pressing and directed. Directed at him, for him. He has not observed the bands of color taking shape; he knows only that it is suddenly there, solid and perfect, and through its clean gateway shines a radiant slice of paradise.

At the moment the rainbow makes its appearance, he is standing, and the next moment kneeling, by the grave of his wife, Mercy.

He, a stonecutter by trade, has set her gravestone himself, a mottled wedge split thin and polished, with her name and dates deeply incised on its center.

Mercy Stone Goodwill

1875-1905

Greatly Beloved

✻

Deeply Mourned

The work of engraving had distracted him in the first terrible days, but almost immediately he perceived that the monument was pitifully inadequate, too meagre and insubstantial for the creature who had been his sweetheart, his wife, his treasure. Now, each day, he carries one or two small stones from the quarry, caching them carefully behind a clump of willow at Taylor's Corners, not far from the turning at Pike's Road. He chooses the stones carefully, for he has formed an odd resolution, which is that he will set them without mortar. Gravity alone must hold them in place, gravity and balance, each stone receptive to the shape of those it rests against and in keeping with the abstraction that has lately filled his head like a waking reverie, a dream structure made up of sorrow mingled with bewilderment. Again and again, he hears a voice, the same voice, asking the same question: why had his wife not told him a child was expected?

Already the walls of the tower have risen to shoulder-height. Some of the stones he sets are no bigger than his thumb or his fist, some measure eight or ten inches across or more. This morning, in the rainbow's garish light, their surfaces seem to dance in rhythm with the clusters of goldenrod that had opened up everywhere in recent days. Sun and rain, cloud and light, flower and stone—they are each so closely bound together, so almost prophetically joined, that he experiences a spasm of joy to find himself at the heart of such a holy convergence. His chest fills up with his own noisy relief, a cry of ecstasy, a wild howl of joy.

He had thought himself alone in the world, but in fact he is a child of this solid staring rainbow, and of the persevering forms of light and shadow, of substance and ephemera. A child of the earth.

Only later, walking home across the rutted fields, does he recall and give honor to the author of his happiness, uttering God's blameless name aloud.

• • • • •

It's Sunday morning now, a fine June morning, and the iron bell in the steeple of the Tyndall Methodist Church is calling the faithful to worship, but my father is not drawn by this clanging and banging.

Religion has not made a church-goer of Cuyler Goodwill. In the early days of his conversion, he attempted, three or four times, the morning service in Tyndall, and once, only once, he walked seven miles west to the settlement at Oakmidden where he sat, bewildered, through the arcane rites of a Greek Orthodox mass. The noisiness of public worship—singing, praying, chanting, preaching—make him uneasy. The vestments of holy men, even the simple white Methodist collar, abrade his sensibilities, crowd him to the edge of his belief, and the dusted, rafted, churchy spaces assault him with their perfume and polish, belittling him, taunting him. Moreover, his natural instincts feel constrained by the order of holy service, the breathy invocations and amens and numbered hymns, and afterwards the obligation to shake hands with others of the congregation, to greet them soberly, to engage his tongue in social exchange—all this rubs the man the wrong way.



WORCESTER CITY HALL, WORCESTER, MASS.
(See Plates IV-VI.)

(Frontispiece.)

STEREOTOMY.

BY

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AND

HOWARD C. IVES.

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STEREOTOMY.

CHAPTER I.

DEFINITIONS AND CLASSIFICATIONS.

ART. 1. DESCRIPTION OF BUILDING STONES.

1. **TRAP** is an igneous rock of great strength and durability, but owing to its lack of cleavage and its exceeding toughness it is of little use as a building stone. Its principal use is as a road metal and as the aggregate for concrete.

2. **GRANITE** is a metamorphic, unstratified rock, the strongest and most durable of all the stones in common use. It generally breaks with regularity and can be quarried into simple shapes without difficulty. It is hard and tough and is not easily worked into elaborate forms. Its great use is for massive structures, such as piers, abutments, docks, and building walls, where simple blocks are required.

3. **LIMESTONES**, composed chiefly of carbonate of lime, are of great variety in color, composition, and usefulness for building purposes. Limestone is a sedimentary rock, stratified in layers of varying thickness.

The light-colored and fine-grained limestones are often sawed into ashlar, and thus worked make an excellent building material. They are generally less easily worked under the chisel than the sandstones. Some of the softer limestones, however, possess the valuable quality of being easily wrought when taken from the quarry, and of hardening after exposure and seasoning.

The cream-colored limestones of the Paris basin, Topeka stone of Kansas, and the Bermuda stone have all been used in building walls that were planed down and elaborately ornamented at small expense.

4. **MARBLES**.—Commonly any limestone that will take a polish is termed a marble, but the name is properly applied to limestone that has been metamorphosed to a crystalline texture. Marbles are easily worked and form the most beautiful of building stones.

5. **SANDSTONES** are stratified rocks composed chiefly of grains of sand more or less cemented and consolidated. The size of the sand grains, the cementing material, the compactness of the grains, and the presence of other ingredients, such as lime, iron, alumina, magnesia, etc., modify the character, color, and durability of the sandstones.

When of nearly pure silica and well cemented, sandstones are as resistant to weather as granite, and very much less affected by the action of fire.

When first taken from the quarry they are frequently very soft, but on exposure become hard.

Sandstones are abundant in nearly all countries, are quarried with great ease, are wrought with the chisel much easier than granite, limestone, and most other building stones, and, taken as a whole, may be considered as among the most durable and valuable of building materials.

6. **LOCAL NAMES**.—There is a great variety of names applied to building stones which are derived from the appearance of the stones, from the uses to which they are put, the locality from which they are quarried, etc., which are often very confusing. No classification can be given to cover such nomenclature, and familiarity with local customs can alone enable one to determine the meaning of such names.

7. **ARTIFICIAL STONE**.—There are several kinds of artificial stone which are used for architectural purposes, which are made of combinations of hydraulic cement, sand, gravel, broken stone, etc. No attempt will be made to mention or describe the various patented mixtures.

Concrete, which is rapidly replacing stone-block masonry for

Concrete, which is rapidly replacing stone-block masonry for many classes of structures, is a mixture of hydraulic cement, sand, and broken stone or gravel. It may be moulded into blocks of any desired shape or used in mass, making the structure a monolith.

The use of concrete usually precludes the need for drawings of separate parts or blocks, but there remains the work of designing the forms and moulds which are needed to give the structure the shape and dimensions desired.

The exposed faces of concrete structures are often made to represent block masonry, and may be given the same finish with tools similar to those later described under stone-cutting tools.

For description of building stones, their chemical and physical properties, durability, cost, etc., and for a full discussion of concrete, see Baker's "Masonry Construction"; "Stones for Building and Decoration," by George P. Merrill.

ART. 2. QUARRYING.

8. Quarrying is an art which can only be acquired by actual experience in the quarries. There are, however, certain facts that the student should be acquainted with if he is to economically plan a masonry structure.

All stones have more or less well defined lines that determine the easiest method of breaking the block from the quarry and which determine the size of the blocks that can be quarried.

In sedimentary rocks (sandstones and limestones) there is a 'bedding' due to the fact that the sediments were laid down in approximately parallel layers. These stones split easily along planes parallel to the beds, and, if the natural layers are of great thickness, this must be done in quarrying.

There are also in sedimentary rocks two sets of 'joints' which, with the beds, subdivide the deposit into a more or less regular system of blocks. The set of joints which are approximately perpendicular to the beds and have a general direction with the dip of the rock are called 'dip' or 'end joints.' The second set, which are approximately perpendicular to the beds and at right angles to the end joints, are termed 'strike-joints' or 'back joints.'

Granite and other eruptive rocks have no beds, but usually show the dip and strike joints and sometimes have 'bottom' joints which facilitate the quarrying in the same way as do the beds of sedimentary rocks.

9. **Quarrying by Hand-tools**.—Sandstone, limestone, and sometimes granite may occur in thin layers that can be loosened by the use of hand-tools, without explosives. Stone so thin that it can be quarried by the aid of the pick, bar, and hammer is seldom of a quality fit for buildings.

Stone in layers of considerable thickness can be quarried by the aid of the plug-and-feather method. A line of holes, usually $\frac{3}{4}$ inch in diameter, is drilled along the line desired, and the plugs are inserted between the feathers and driven tightly, care being taken to increase the pressure from the several plugs with uniformity. By this method stones may be broken along lines not coincident with the natural lines of cleavage.

10. **Quarrying by Explosives**.—Usually for quarrying of large stones or in getting out any size of stone from quarries carrying massive rocks, some explosive, coarse gunpowder or low-power dynamite, is used to free the large masses, which are then subdivided by the plug-and-feather method.

The tools used for drilling the holes for the explosive are the *churn-drill*, the *jumper-drill*, and *machine drills*.

The *churn-drill* is a long heavy drill which is raised by two men, let fall, caught on the rebound, raised, rotated a little, and let fall again, thus cutting by the force of the falling bar, no hammer being used.

The *jumper-drill* is similar to the hand-drill which is held and struck by one man, except that it is usually larger. It is held by one man, who rotates it slightly between the hammer-blows

which are delivered by two men striking in turn.

Machine drills are largely replacing hand-drills in all large quarries. There are two types of machine drill, the percussion and the rotary.

Percussion-drills, driven by steam or compressed air, have a drill attached to the end of a piston-rod, the drill being thrown against the rock by the pressure of the steam or air in the piston. The drill is given a slight rotary motion between the strokes, and is fed down to the work by the attendant by means of a crank and screw.

In rotary drills the drill is forced steadily against the rock, and is revolved about its axis by power. In the *diamond drill* the end of the steel bar may be so set with diamonds that all the material within the circumference of the hole is ground to powder, or the diamonds may be set about the circumference of a hollow drill, thus cutting an annular space and leaving a core which may be broken off. This drill is much used in prospecting and for the examination of sites for foundations.

Rotary drills with steel cutting-teeth are used in some cases.

Channeling-machines are similar in their action to the percussion drills, and enable a channel to be cut around a block.

Gadding-machines are for the purpose of drilling horizontal holes under a block which may have had a channel cut around it. These holes are used for wedging the block from the quarry. Gadding-machines may be of either the percussion or the rotary type.

11. The product of the quarry is stone, in approximately rectangular blocks, from which all other forms must be wrought by the methods stated in Art. 3, Chap. II. The designer should be familiar with the quarries from which his stock is likely to come, that he may specify sizes that are practical and economical for these quarries to furnish.

See "Stones for Building and Decoration," Merrill; Baker's "Masonry Construction"; Drinker's "Tunneling, Explosives, and Rock-drills."

ART. 3. STONE-CUTTING TOOLS.

12. For a clear understanding of the methods of preparing stones for use it is necessary to describe the tools used.

A committee of the American Society of Civil Engineers prepared a classification of stone-cutting tools, together with definitions of terms used in masonry construction, which have been followed quite generally by engineers and architects. The following is taken from that report.*

"The *Double-face Hammer*, Fig. 1, is a heavy tool weighing from 20 to 30 pounds, used for roughly shaping stones as they come from the quarry and knocking off projections. This is used only for the roughest work.

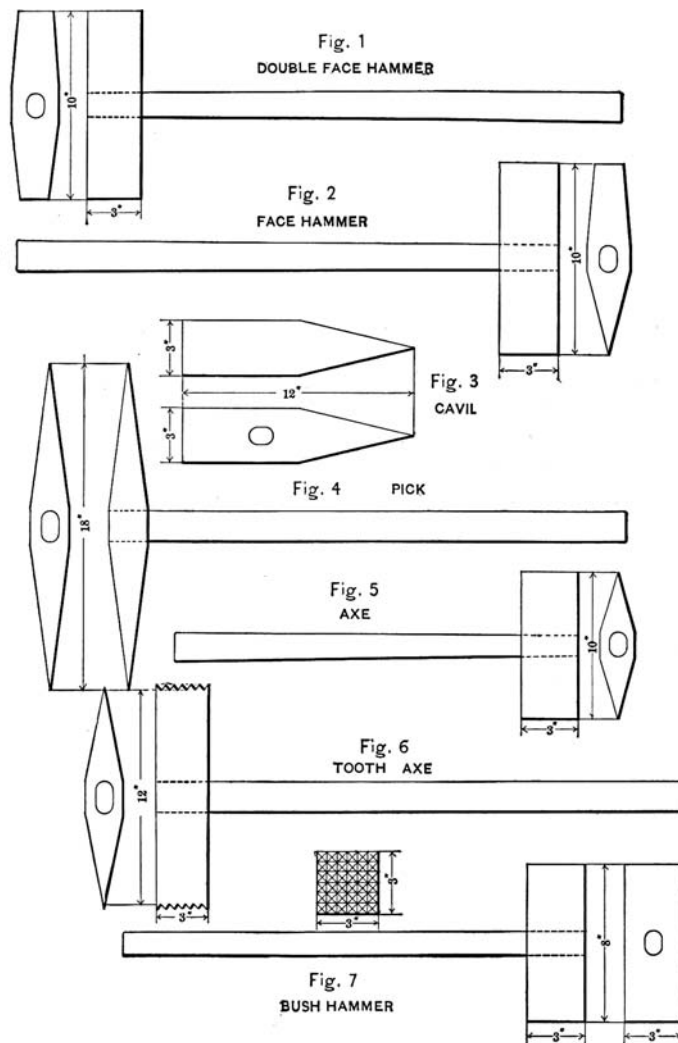
"The *Face-hammer*, Fig. 2, has one blunt and one cutting end, and is used for the same purpose as the double-face hammer where less weight is required. The cutting end is used for roughly squaring stones, preparatory to the use of finer tools.

"The *Cavil*, Fig. 3, has one blunt and one pyramidal, or pointed end, and weighs from 15 to 20 pounds. It is used in quarries for roughly shaping stones for transportation.

"The *Pick*, Fig. 4, somewhat resembles the pick used in digging, and is used for rough-dressing, mostly on limestone and sandstone. Its length varies from 15 to 24 inches, the thickness at the eye being about 2 inches.

"The *Axe*, or *Peau-hammer*, Fig. 5, has two opposite cutting edges. It is used for making drafts around the arris, or edge of stones, and in reducing faces, and sometimes joints, to a level. Its length is about 10 inches and the cutting edge about 4 inches. It is used after the point and before the patent hammer.

"The *Tooth-axe*, Fig. 6, is like the axe, except that its cutting edges are divided into teeth, the number of which varies with



FIGS. 1-7.

the kind of work required. This tool is not used on granite and gneiss cutting.

"The *Bush-hammer*, Fig. 7, is a square prism of steel whose ends are cut into a number of pyramidal points. The length of the hammer is from 4 to 8 inches, and the cutting face from 2 to 4 inches square. The points vary in number and size with the work to be done.

"The *Crandall*, Fig. 8, is a malleable-iron bar about two feet long, slightly flattened at one end. In this end is a slot 3 inches long and $\frac{3}{8}$ inch wide. Through this slot are passed ten double-headed points of $\frac{1}{4}$ -inch-square steel, 9 inches long, which are held in place by a key.

"The *Patent Hammer*, Fig. 9, is a double-headed tool so formed as to hold at each end a set of wide thin chisels. The tool is in two parts which are held together by the bolts which hold the chisels. Lateral motion is prevented by four guards on one of the pieces. The tool without teeth is $5\frac{1}{2} \times 2\frac{3}{4} \times 1\frac{1}{2}$ inches. The teeth are $2\frac{3}{4}$ inches wide. Their thickness varies from $\frac{1}{2}$ to $\frac{1}{4}$ of an inch. This tool is used for giving a finish to the surface of stones.

"The *Hand-hammer*, Fig. 10, weighing from 2 to 5 pounds, is used in drilling holes, and in pointing and chiseling the harder rocks.

"The *Mallet*, Fig. 11, is used where the softer limestones and sandstones are to be cut.

"The *Pitching-chisel*, Fig. 12, is usually of $1\frac{1}{2}$ -inch octagonal steel, spread on the cutting edge to a rectangle of $\frac{1}{2} \times 2\frac{1}{2}$ inches. It is used to make a well-defined edge to the face of a stone, a line being marked on the joint surface to which the chisel is applied,

*Trans. A. S. C. E., vol. vi. pp. 297-304.