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A SMALL BASEMENT CORED ANTICLINAL WARP IN THE BASAL CRETACEOUS SEDIMENTS NEAR CHERAW, SOUTH CAROLINA

By

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The contact between crystalline basement rocks of Paleozoic (?) age and the overlying Coastal Plain sediments is generally poorly exposed and seldom seen in South Carolina. One road cut in Chesterfield County, however, not only shows the contact clearly but illustrates an interesting structural relationship between the basement and the overlying unconsolidated sediments.

The following section is exposed in the cut on the southwest side of US 52, six miles northwest of Cheraw and 0.5 miles northwest of Westfield Creek bridge. Refer to Figure 1 for a sketch of the outcrop.

SURFICIALS

5. Quartz cobble pebble conglomerate; unconformable contact with underlying beds.

MIDDENDORF FORMATION (Upper Cretaceous)

4. Medium sand (sd. 83%, si. 5%, cl. 12%); "moderate" yellowish orange (10YR 7/6); sand contains weathered feldspar grains, layer of coarse pebbles 0.1 to 0.2 foot thick about 0.5 foot above base; other pebbled layers scattered within sand; planar, tabular, concave, low angle, medium scale cross-bedding below ferruginous layer near center of outcrop; sand above ferruginous layer contains many clay fragments.
3. Silty clay (sd. 4%, si. 38%, cl. 58%) massive; "light" grayish pinkish orange (5YR 8/2) stained moderate yellowish orange, (10YR 4/6); clay minerals, kaolinite. Toward northwest part of cut clay bends over basement hill; projection dips are as high as 40°. Toward southeast end of cut clay contains several splits of quartz pebble conglomerate and of sand and clayey sand.
2. Silty sand (sd. 72%, si. 18%, cl. 10%); very pale orange (10YR 8/2); scattered subrounded pebbles (modal size about 25 mm); at top, quartz pebble conglomerate with clayey sand matrix, 0.6 foot thick; at bottom, quartz pebble conglomerate with reworked pebble sized fragments of basement rock, up to 1 foot thick.
1. Weathered bedded argillite, foliation strikes N65°E and dips 85°NW, bedding contorted. Clay minerals, sample at NW end of cut contains almost pure montmorillonite, sample at NW end of SE part of cut contains illite and kaolinite.

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UNITS 2, 3, AND 4 ARE IDENTIFIED AS THE MIDDENDORF FORMATION OF CRETACEOUS AGE (HERON, 1958) BECAUSE OF THE GROSS LITHOLOGY AND THE STRATIGRAPHIC POSITION. UNIT 5 IS PART OF THE "BLANKET" GRAVEL FOUND IN TERRACE DEPOSITS RELATED TO THE PEEDEE RIVER.

THE STRUCTURES SEEN IN THE OUTCROP ARE DESCRIBED AS A BASIN OR SYNCLINAL WARP ADJACENT TO AN ANTICLINAL WARP. THE ANTICLINAL WARP IS DRAPED OVER A HILL-LIKE MASS OF BASEMENT ROCK. IT PLUNGES TOWARD THE NORTHEAST FOR ON THE OPPOSITE SIDE OF THE ROAD THE BASEMENT CORE IS NOT VISIBLE, BUT THE BASAL LAYERS OF QUARTZ-PEBBLES IN UNIT 4 CLEARLY OUTLINE ITS FORM.

THE ORIGIN OF THE WARPING IS NOT CLEAR, AND SEVERAL HYPOTHESES MUST BE CONSIDERED.

(1) A TECTONIC ORIGIN FOR THE STRUCTURE IS UNLIKELY BECAUSE THERE IS NO EVIDENCE OF CRETACEOUS OR POST-CRETACEOUS TECTONIC ACTIVITY IN THE REGION THAT WOULD PRODUCE FOLDING. A TECTONICALLY PRODUCED FOLD WOULD CERTAINLY HAVE AN APPEARANCE DIFFERENT FROM THAT SHOWN IN THE CUT.

(2) A SEDIMENTARY ORIGIN FOR THE STRUCTURE IS COMPLETELY UNTENABLE BECAUSE THE INITIAL SEDIMENTS COULD NOT HAVE HAD THE PRESENT CONFIGURATION. THE SILTY CLAY OF UNIT 3 MAINTAINS AN EVEN THICKNESS (EXCEPT WHERE LOCALLY REMOVED BY RECENT EROSION) AS DOES UNIT 2 OVER THE TOP OF THE "HILL" AT THE NORTHWEST END OF THE CUT. IT SEEMS HIGHLY UNLIKELY THAT ANY METHOD OF SEDIMENTATION INVOLVING LIQUID TRANSPORTATION AGENTS COULD HAVE POSSIBLY DEPOSITED SEDIMENT OVER A "HILL" IN THE MANNER ILLUSTRATED IN THE CUT. A TYPE OF MASS-WASTING INVOLVING THE WHOLESALE MOVEMENT OF THE UNITS DOWN NEARBY SLOPES (IN CRETACEOUS TIME) COULD HAVE RESULTED IN THE DEPOSITION OF THE SEDIMENTS IN A POSITION SIMILAR TO THAT IN WHICH THEY NOW OCCUR. BUT A MASS-WASTED PRODUCT SHOULD NOT BE AS EVENLY LAYERED AS UNITS 2 AND 3, NOR WOULD IT BE LIKELY TO HAVE THE TEXTURAL CHARACTER OF THE TWO UNITS.

(3) DIFFERENTIAL COMPACTION OF THE CRETACEOUS SEDIMENTS WOULD BE A LIKELY MEANS OF FORMING THE FOLD IF IT WERE NOT FOR THE FACT THAT UNITS 2 AND 3 MAINTAIN AN ESSENTIALLY CONSTANT THICKNESS OVER THE BASEMENT "HILL". DIFFERENTIAL COMPACTION WOULD BE ESPECIALLY NOTICEABLE IN THE HIGH CLAY OF UNIT 3.

(4) THE MOST LOGICAL HYPOTHESIS IS THAT THE CRETACEOUS BEDS WERE DEPOSITED ESSENTIALLY HORIZONTALLY OVER A FLAT BASEMENT FLOOR AND LET DOWN TO THEIR PRESENT POSITION AS A RESULT OF COMPACTION OR SOLUTION OF THE UNDERLYING BASEMENT ROCKS. SOLUTION OF A $CaCO_3$ COMPONENT OF THE ARGILLITE MAY HAVE AIDED COMPACTION (T. L. KESLER, ORAL COMMUNICATION). CALCIUM CARBONATE IS KNOWN TO OCCUR ELSEWHERE IN THE CAROLINA SLATE GROUP. THE MOST SOLUTION WOULD HAVE HAD TO OCCUR IN THE CENTRAL PART OF THE EXPOSURE BECAUSE COMPACTION FOLLOWED BY LET DOWN IS MOST PRONOUNCED IN THIS AREA. IF CONSIDER-

ABLE SOLUTION DID OCCUR, THE RESULTING COMPACTION WOULD DESTROY THE TEXTURE AND STRUCTURE OF THE ARGILLITE. THE BASEMENT IS NOT VISIBLE IN THE AREA OF MAXIMUM DEPRESSION OF THE OVERLYING BEDS, BUT IN THE BASEMENT EXPOSURE NEAREST THE MAXIMUM DEPRESSED AREA THE BEDDING IS VISIBLE BUT IS DISTURBED AND HIGHLY CONTORTED.

VARYING SUSCEPTIBILITY OF THE ARGILLITE TO WEATHERING (NOT NECESSARILY WITHOUT SOME SOLUTION) COULD BRING ABOUT DIFFERENTIAL COMPACTION OF THE BASEMENT ROCKS WITH THE RESULTING LET-DOWN OF THE OVERLYING CRETACEOUS SEDIMENTS. THE COMPOSITION OF THE BASEMENT ROCKS DOES VARY CONSIDERABLY WITHIN SHORT DISTANCES. THE COMPOSITION VARIATION IS REFLECTED IN THE CLAY MINERALS OF THE WEATHERED MATERIAL. IN THE "HILL" AREA, MONTMORILLONITE IS FOUND; AND IN THE BASEMENT BEDS NEAREST TO THE AREA OF MAXIMUM DEPRESSION ILLITE AND KAOLINITE OCCUR. THE VARIABLE COMPOSITION IS ALSO REFLECTED IN THE RESISTANCE TO WEATHERING OFFERED BY DIFFERENT AREAS OF BASEMENT ROCKS. THE ARGILLITE IN THE "HILL" AREA IS WEATHERED, BUT IT IS TOUGH WHEREAS THE ARGILLITE NEAREST THE AREA OF MAXIMUM DEPRESSION IS COMPLETELY WEATHERED TO A SOFT MASS VERY HIGH IN CLAY.

UNDOUBTEDLY, WEATHERING AIDED BY SOLUTION RESULTED IN DIFFERENTIAL COMPACTION OF THE BASEMENT ROCKS WITH THE PASSIVE LET-DOWN OF THE OVERLYING CRETACEOUS SEDIMENTS. THIS TOOK PLACE AFTER DEPOSITION OF THE MIDDENDORF FORMATION AND BEFORE DEPOSITION OF THE SURFICIAL GRAVELS.

REFERENCE CITED

HERON, S. DUNCAN, JR., 1958, STRATIGRAPHY OF THE OUTCROPPING BASAL CRETACEOUS BEDS BETWEEN THE CAPE FEAR RIVER, NORTH CAROLINA, AND LYNCHES RIVER, SOUTH CAROLINA: GEOL. SOC. AMERICA BULL., V. 69, P. 1582.

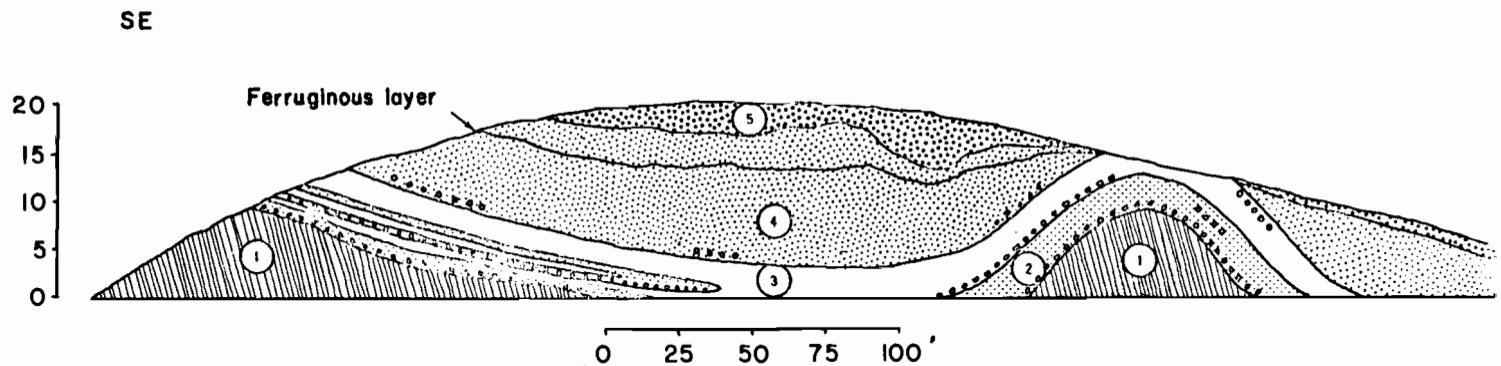

FIGURE 1 - SKETCH SHOWING LOCAL WARPING IN BASAL CRETACEOUS SEDIMENTS ON US 52 SIX MILES NORTHWEST OF CHERAW, CHESTERFIELD COUNTY, SOUTH CAROLINA.

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The Primitive Limestone Belt.

It has long been known, that limestone of excellent quality was exposed at the Limestone Springs, in Spartanburg; and at later times, sundry other exposures have been found, and the limestone has been quarried in several places, for the reduction of ore at the neighboring iron furnaces; and also was burned to lime, to supply, at a very high price, the very small demand for lime, for cement and other mechanical purposes. It is but lately that the number of natural exposures of limestone ascertained, have made it seem probable, not only that the limestone forms a continuous and connected narrow belt across the State, but further, that the limestone may be successfully sought in many other places than it has yet been seen in its apparent course.

Extending from the nearest similar exposure in North Carolina, this stripe of limestone enters South Carolina in York, a little west of King's Mountain, and is first seen on one of the upper forks of King's Creek. Thence it is seen exposed in almost every valley in the course of the line, and at distances apart, from a few hundred yards to two miles. On the following plantations are presented exposures in York; commencing near the North Carolina line, first on Hamright's land, and thence, in order, on the lands of Etter, Whesant, Wilson, Bird, Harden, W. Black, Hauser, the King's Mountain Iron Company, (two localities,) and the South Carolina Iron Company, on Broad river, and just above their iron works. Next, across Broad river, and in Spartanburg, on the lands of Stacey, the South Carolina Company, (two places,) Limestone Springs, Otterson and Watkins; and on Thompson's plantation, on Pacolet river, about 2 miles below the Hurricane Shoals. The last named exposure only was artificial, it having been reached in the digging of a well; and this is the extreme limit of the limestone in Spartanburg yet known, though the Pacolet Springs and Cedar Springs, both further on, are of limestone water, which would indicate the stone to be there accessible, if dug for.

Throughout this line, there prevails a general uniformity of the appearance and character of the limestone. It is seen protruding above the surface of the earth only in bottoms, and only in a few and but slightly elevated masses, before excavations are made, which have generally shewn the stone to rise much higher and abruptly in the neighboring hill sides, and abundant in accessible and available quality. Though seen only in the valleys, still it is not because the limestone preserves any thing like an equal elevation. On the contrary, the limestone at one exposure between King's Mountain and Broad river, (though in a valley,) is fully 350 feet perpendicular, higher than elsewhere, in another deeper valley within a few miles.* The stratification of the limestone is seen generally greatly inclined, and very different in degree, and also in direction. It is in some places almost vertical, and at others, though rarely, nearly horizontal. The color is generally blueish gray. At the Limestone Springs, part is white. The stone is mostly nearly free from any admixtures worth consideration,

* This fact is known from the running and levelling of one of the experimental lines of survey, for the designed (and fortunately abortive,) Cincinnatti and Charleston Rail Road.

as effecting the quality—unless perhaps it be of magnesia, of which the proportion has not yet been determined; and if known, it is a disputed point, whether its presence detracts any value from lime, either for cement or for manure. The formation is primitive; it has the ordinary hardness and texture of compact limestone. The grain is sometimes close, and the fracture dull—but in others, highly and beautifully crystalline.

Proceeding in the same course, and after a wide interval of about 36 miles, in which no limestone has yet been found, the next exposures known are in Laurens district, on the south side of the south fork of Raiburn's Creek, and are seen from one and a quarter to one and three quarter miles above the junction of that with the north fork. There are several different exposures within the limits of half a mile along the course of the creek, and indicating a visible width of the limestone belt, at this place, of several hundred yards. This is on the land of Mr. J. Garlington, and 9 miles from Laurensville, in a direction south of west. The existence of limestone here has not been long known. A kiln has been erected within the past year, and the business of burning lime for sale commenced.

The next known exposure was made accidentally some years ago, by the digging of a well, on the highest ridge land, south of and next to Reedy river, and about 5 miles from the last named locality. At 64 feet deep, a peculiar rock was reached, and quarried by blasting, and excavated and drawn up for some considerable depth. It was not then suspected to be limestone, but is now known to be such, by comparison with the neighboring limestone very recently discovered. These are, first, on Waite's and Clardy's lands, along a branch of Walnut creek, which is a mill stream, emptying into the Saluda, and about 1 1-2 to 2 miles from that river; and next on Barmore's land, about half a mile from the Saluda, and about a mile above Pinson's ford across that river, and rather more above the mouth of Turkey Creek,—and which last exposure is the extreme south-western limit of this range of limestone, so far as yet traced in South Carolina.*

The limestone quarried on Raiburn's creek, exhibits great difference of quality. A part is so impure that it makes a very poor lime, and is no longer burnt, since its character has been ascertained by that costly mode of trial. There is, however, an abundance, of good quality—a pale blue crystalline stone, with very little of any foreign matter intermixed. But the stone exposed on Waite's and Clardy's lands and on Barmore's, is very pure, and indeed is, so far as seen, a beautiful white crystalline marble. The natural exposures at the latter place, are seen not more than 40 yards in extent; at the former, for more than 100 yards, and where highest, the limestone is seen 10 feet above the bottom in which it rises, which height is much greater than was exposed naturally at Garlington's, and at other

* The following statement will serve as evidence of the slight value as yet attached to limestone, even at nearly the exposure most advanced towards a country and a market destitute of lime, and therefore in the most valuable position to command purchasers. When examining the limestone on Clardy's land, (which is in fact a beautiful crystallyzed white marble, as well as bein excellent limestone, for cement and manure,) I heard that the small tract of land containing it was then advertised for sale at public auction, for the purpose of division among heirs. It has since been sold; and in compliance with my request, a gentleman of the neighborhood has written to inform me of the result, in the following words: "The land brought a small fraction over $4 per acre. Attention was particularly directed to the limestone on it; but the land did not bring a cent more on that account."

places, where excavations for quarrying have shown the stone to rise high and to be abundant and easy of access.

The course of the line of limestone, as marked on the annexed map of the State, proceeding from the north, is, first, nearly south-west, and becoming more southerly in Laurens, and approaching its southern known extreme. The whole line forms a gentle and nearly regular curve. If future investigations should prove that the two remote parts of the limestone do not belong to the same range, (as supposed above,) but to two distinct and separate ranges, then the southern continuation of the Spartanburg limestone would probably pass somewhere under Greenville and Anderson districts, and the northern extension of the Laurens limestone through Union, and perhaps Chester. In either case, the Laurens range must, if continued, pass under Abbeville. And if persons who are intimately acquainted with the features of the ground, would carefully search for the limestone in the course of the lines designated above, and especially in places near the farthest extended known exposures, it is probable that in a short time there would be discovered twice as many exposures, and much more than double the extent of lime now known. With the necessary local knowledge, the examiner should proceed in the supposed line of direction, and examine the rocks showing in every deep valley, and especially crossing the beds of rivers and smaller streams. The touching with acid is much the easiest, and also the surest mode of distinguishing limestone from all other hard rocks.

There is another narrow belt of limestone, extending from Habersham in Georgia, and exposed in Pickens district, near the out-let of Brasstown creek, into the Toogoloo, (or main branch of the Savannah,) and also, about 12 miles distant, near to and north of the Chauga river. Taking these two points as indicating the course of the line, it is nearly north-east and south-west; or something like parallel to the supposed general course of the lower range of limestone, and also, to that of the Blue Ridge mountains. Some lime has been burnt of the Pickens stone, but very little use made of it for any purpose; for which neglect the high price offers a sufficient, though not the only operating cause.

Even though the limestone of the upper districts should not be exposed and found available in more places than it is now known, still it offers immense benefit to the agriculture of the surrounding country. But to reach this end, and to produce any important benefit to the sellers as well as to the buyers of lime, two new conditions must exist, which will mutually sustain and give value to each other. These are, a greatly reduced price for the lime, and a greatly increased demand and consumption. While the lime sells, as now, from 25 cents to 40 cents the bushel, there will never be enough consumption to make the business of burning lime worth much. But if it sold at 10 cents, which price, a constant and certain and large demand would make abundantly profitable, the lime would be conveyed for manure, 20 miles by land-carriage, and much further by aid of the intersecting navigable rivers—making a business of great profit to both sellers and buyers, and of great and permanent improvement to a large space of territory.

These statements vary so much from existing prices and prevailing opinions in South Carolina, that it is proper to accompany them with some evidence—which will be done as concisely as the occasion requires. The

facts which will be adduced, are such as have been hastily gathered, where but few authorities and sources of information could be referred to, and therefore, as proof, they probably are not the most full. Nevertheless, they will be ample for my purpose. Professor Low, (in his Elements of Agriculture,) states the price of lime, (unslaked, as is always understood, when not stated otherwise,) in the borders of England and Scotland, to be three pence sterling the bushel, or about 6 cents. The only statement of price in France I have seen, is in the excellent and elaborate treatise of Harrenfratz.* It is there mentioned incidentally, that at Barres the price was 8 to 10 *sous*, which is about as many cents. In that country, fuel is enormously dear. In Ireland, as I have learned severally from two very intelligent and observant gentlemen from that country, the price of lime is 6 pence per barrel, (of 4 bushels,) and the charge for burning the stone brought to the kiln is 2 1-2 pence the barrel. The latest European authority that I have, is in Johnson's Farmer's Encyclopedia, just published in this country, which states so low a price for lime, that I prefer to quote the whole passage. The author says, (in the article "Lime.") "The price of fuel, and readiness of access to the limestone or chalk, of necessity, governs the price of lime; in some districts of the north [of England] it is made by the farmers for not more than one penny to three half pence the bushel." In Lancaster, Pa., lime is sold at the kilns at 12 1-2 cents, where fuel is high. Excellent lime is brought in large quantities, slaked, and the vessels loaded in bulk, from the Schuylkill and the Hudson, to James river in Virginia, and sold to the farmers by the cargo, and upon previous contract, at 9, 8, and even as low as 7 cents the bushel—the last named price being for a very large contract, within my knowledge, recently made. As stone lime, if good, gains at least 100 per cent in bulk by being slaked, and converted from compact stone to impalpable powder, these prices for slacked lime should be doubled, for the proper mode of estimate; and which shows that lime may be and is continually brought from 5 or 600 miles, and by sea, and sold at prices equivalent to 16 and even as low as 14 cents the bushel. Now, even if we had no facts nearer home than these, it would be manifest that lime may be burnt as easily in South Carolina as elsewhere, and sold cheaper than the highest of these prices, and not much dearer than the lowest. For if labor be higher here than in Europe, and more labor be required for removing earth and blasting, on the other hand fuel is much cheaper, and (as yet) so is the land containing the lime-stone. But I have more satisfactory proof, in estimates and facts obtained in regard to the very lime under consideration. At the Limestone Springs, in Spartanburg, where the stone was first discovered, and has been longest and most largely burned for sale, the business is conducted, as every where else that it has been attempted, with very little knowledge of the process, or economy of means. The kiln is badly constructed, and there is great waste of fuel, and of heat, and of time in burning, as well as labor in blasting the stone in the quarry. Every part of the labor was hired and paid for at fixed rates; and thus the occupant, Mr. J. C. Janney, knew precisely the cost of every charge of the kiln; and of all which, at my request, and for this purpose, he made the following accurate estimate and statement of actual expenses,

* *Traite Theoretique et Pratique de l'Art de Calciner la Pierre Calcaire.*

for the burning of 600 bushels of lime, which is the quantity contained by the kiln :

"Quarrying or raising limestone (or blasting, breaking, and heaping,) say 28 loads, of 3,200lbs, at 45 cents the load,	$12 60
Hauling stone to the kiln (about 100 yards or less),	5 00
Filling kiln and burning, (2 men for 5 days, at $1 each),	10 00
Paid for cutting wood, 22 cords, (or price of wood ready cut),	10 90
Hauling the wood,	6 60
	$45 10."

Which is equal to 7 1-2 cents the bushel for the 600 bushels of lime, unslaked. Every expense is charged except the rent of quarry and kiln, which could not be determined ; but which, in large operations, would together scarcely make half a cent more, or raise the cost to 8 cents. Thus, if selling at 10 cents, at the kiln, and with certain and full demand, a nett profit of 25 per cent. would be cleared, even on this very inefficient and very costly mode of operations. And if a proper kiln were constructed, so as to save the fuel, the heat, the time and the labor, that are now wasted, and the quarrying were done in the best manner suitable for a large business, there can be little doubt that the above stated expenses might be greatly reduced.

Among other valuable services for which I am indebted to the knowledge and kind aid of Mr. M. Tuomey, he visited and examined the lime-kilns in Philadelphia on the Schuylkill, at my instance, and prepared accurate drawings and descriptions of the best kinds there in use, which, together with all the statistics of the business, as there conducted, showing the amount of labor, expenses, and prices, &c., will be here annexed, for the benefit of any person who may desire to commence the business of lime-burning in South Carolina, in a proper manner for economy and profit—than which a more profitable business can scarcely be undertaken, even if with a view of selling lime, and for other than agricultural uses.

" The best site for a kiln will be a hill side convenient to the lime-stone quarry, or marl deposit. In such a situation, besides the facility afforded for charging the kiln, the expense of masonry will be much reduced, as little more than a breast wall will be required. This wall should present a portion of a reversed arch, the convex part being towards the fire. This form evidently offers the greatest resistance to the expansive force of the heat from the kiln. The interior of the kiln must be lined with some fire-proof material; some varieties of sand-stone and talcose rock, where they can be procured, will furnish good substitutes for fire-brick.

" The only difficulty to be apprehended in burning hard marl with wood, is that when the burning proceeds to a certain point the stones composing the arch are apt to crumble and fall in. The most compact masses should therefore in all cases be selected for the construction of the arch.

" Minute directions will scarcely be necessary, as prudence will dictate to every man on commencing the business of lime-burning, that an experienced hand be employed, even at an additional expense, at least until the ordinary hands have acquired sufficient experience.

" The stone used at the kilns in Philadelphia is the refuse from the quarries at Norristown ; it is boated down the river a distance of 17 miles, and delivered at the kilns at 85 cents per ton—which quantity, when burned, furnishes 15 bushels of [unslaked] lime. The small coal used in the perpetual kilns costs $2 a ton—a ton being sufficient to burn 100 bushels of lime. Where wood is used, 15 cords of oak-wood (which is bought at $3 per cord) will burn 1,000 bushels. Two men are employed at a kiln at $1 each a day. The time required to burn a charge of 1,000 bushels varies from 48 to 60 hours.

"The cost of burning, &c., 1,000 bushels, deduced from these data, will stand thus:

Lime-stone, 66 6–10ths tons, at 85 cents,	$56 61
Oak-wood, 15 cords at $3,	45 00
Hire of 2 hands, 4 days at $1 each,	8 00
Cost of burning 1,000 bushels,	$109 61

Nearly 11 cents per bushel.

"Cost of burning in the perpetual kilns, where coal is used:

Lime-stone, 66 6–10ths tons at 85 cents,	$56 61
Coal, 10 tons at $2,	20 00
Hire of 2 hands, 2 days at $1 each,	4 00
Cost of burning 1,000 bushels,	$80 61

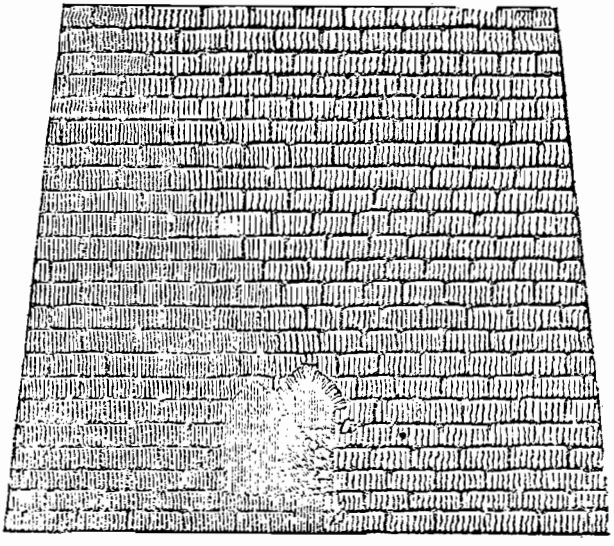
Or nearly 8 cents a bushel.

"Prices of lime delivered at the kilns:

Wood-burned lime per bushel,	18 cents.
Coal-burned lime per bushel,	13 cents.
Slaked lime and ashes,	6 cents.

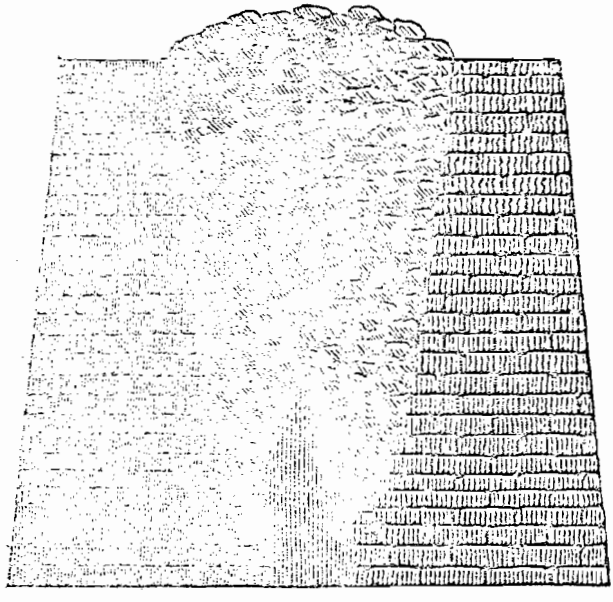
"The wood-burned lime is preferred by bricklayerers and plasters, though for agricultural purposes it possesses no superiority over the coal-burned.

FIGURE 1.



Scale—One-eighth of an inch to a foot.

FIGURE 2



"Fig. 1 represents a front elevation of a kiln in which wood is used as fuel. *C*, an iron door which is closed excepting while wood is thrown in during the burning. The opening, or eye of the kiln, as it is called, is closed with loose stones, leaving the vent *b* and the space at *a* open. At *a* the wood is thrown in.

"Fig. 2 shows a vertical section of the kiln filled and ready for firing. The arch is commenced with small stones on the offset *a a*, each course projecting over the preceding one, until they meet at top. This part of the operation of filling requires some skill.

"The arch requires the largest stones, which should be reserved for the purpose. It is common to heap the stones above the level of the top of the kiln, as represented in the figure. The charge for this kiln is about 1,000 bushels.

"On the top and back of the kiln an opening like a door is left for the convenience of filling, and also for taking out the lime when burned. During the operation of burning the opening is of course closed."

It was not designed in the foregoing directions to indicate the best plan for the construction of a kiln, nor the cheapest mode of burning; but the best and cheapest known in actual operation, where the business is conducted well and on a large scale. There are doubtless more perfect plans of kilns, though more expensive and difficult to construct, which may be referred to, if desired, in various scientific works. Neither was it deemed necessary to describe and figure the perpetual kiln, which is doubtless the best for very large operations, and where coal is the fuel, (or charcoal,) but for which wood will not serve, as is believed by the Schuylkill lime-burners. But compare these *actual* operations and expenses at the Philadelphia kilns, with what is done and with what may be done in South Carolina, and it will be obvious that lime may be burnt here much cheaper, from limestone, and still more so from marl, and marl-stone, because of the greater

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cheapness of the materials, of fuel, and of labor, than these estimates exhibit in regard to Philadelphia.

To offer directions for the practical application of quick-lime would be still more difficult, and is even less called for at this time and in this report, than in regard to marl. A few general observations, however, will be hazarded, and the principal and essential rules stated briefly, for the convenience of those persons who are totally unacquainted with the subject, and may not have ready access to more full instructions in other publications.

The quantities of quick-lime applied have varied greatly in different countries; and this wide variance seems to have grown more out of the difference of cheapness or dearness of the lime, than from any sound reasoning, or experience, or in accordance to calculations of profit. Doubtless a heavy dressing, if not so heavy as to do harm to crop or land, must produce more effect and increase to the acre, than a light dressing. But the abatement of such increased product in lighter limings, is by no means in proportion to the lessening of the dressings applied. And indeed it seems that the lighter the applications to the acre, the greater the effect, for the quantity of lime applied. Thus, the good results experienced from unusually light dressings, have served of late years to reduce the general amount of liming to the acre, while the whole quantity applied has been increasing rapidly every year, wherever the practice has been commenced. The lime used formerly on James River in Virginia, was obtained altogether by the farmers buying and burning oyster shells; and they then usually applied to the acre 72 bushels of burnt shells, (which required 100 bushels raw, to produce,) and which would expand to about 120 or 125 of slaked lime. But Mr. Wm. B. Harrison, on James River, who has limed about 1,500 acres, in this manner principally, and with great success and profit, has since told me that he would have profited much more for his expense if applying at first only half the quantity to the acre, and, of course, spreading his annual amount of lime over double the space. The extent of annual liming has been greatly increased lately on the lands bordering on James River, and destitute of marl, because of the additional and new supply of slaked stone-lime, brought by vessels laden in bulk, from the Schuylkill in Pennsylvania, and Hudson in New York. This slaked lime is generally applied at the rate of 40 bushels only to the acre, equal to 20 bushels of unslaked, or less, when the lime-stone is very pure; and this quantity is deemed by the most judicious limers as sufficient for one application, and it is found to yield satisfactory results and good profits. In a part of France, La Sarthe, it is the established practice to give not quite 12 bushels of lime to the acre, but to repeat it with every commencement of the rotation, which is of three years. This is equal to giving rather less than 4 bushels of lime a year. This mode of repetition is there deemed the best, and the results are at any rate satisfactory. Now, according to my views, with land so treated, a time will arrive when no more lime will be needed, and the then maximum product of the land will never thereafter be reduced. But putting all this theoretical expectation aside, and supposing that, for all future time, 4 bushels of lime, costing 10 cents the bushel, shall be annually given, how small would be the cost, compared to the ordinary products and profits derived from liming! Still, it will be a very great mistake to expect from such light applications the same results as from more heavy dressings.

In whatever manner or quantity quick-lime is applied to land, it is all-im-

portant that it shall be equally distributed over all the surface. Its condition, of being in the smallest possible state of division, and every particle of the impalpable powder being separate and acting, is the cause why a quantity of lime so much smaller than of marl will show appreciable early effects. But if the quick-lime be suffered to get wet in mass, before being completely separated and mingled with the soil, it forms a mortar, and unites and hardens in lumps; which condition, no matter how small the lumps, is a return to something like the former state of lime-stone. These lumps will not be entirely reduced for a long time; and will therefore produce but slight early effect as manure.

To make sure of the equal diffusion of the lime, and with greater ease, it should be given to land already ploughed for some tillage crop, as corn or cotton. If previously slaked, a measured quantity (say a peck, or half a bushel,) should be deposited in the middle of a marked square, of such size as will serve to give to each acre the quantity of lime designed. The lime should be spread as speedily as possible after being thus dropped, carefully and equally, and each heap over its allotted and marked space. And as soon as enough ground is so spread, square harrows, each with 20 or more straight and sharp tines or teeth, should be driven over the land, once or oftener, so as to well mix the lime and surface soil. The lime is then safe; and the subsequent tillage of the crop will mix it thoroughly with the soil, and to sufficient depth.

When the lime is received before being slaked, as is usual, and ought to be preferred, the heaps of burnt shells (or lime-stone) ought to be put out as above directed, of sizes and at distances determined by the quantity desired to the acre. As fast as the unslaked lime is thus deposited, each heap is well covered over by enough of the surrounding ploughed soil, drawn over it by a broad hoe; which is easily and quickly done. This covering of earth, by its moisture in the dryest weather, soon causes the lime to slake; and will serve also to protect the lime from the heaviest fall of rain, which otherwise would convert it first to mortar, and next to stone. As soon as the heaps are slaked, and the earth is in good order for working, the heaps are to be chopped down, the lime and soil which composed them thus well mixed, and then the whole heap spread over its designated space. Then the harrowing follows as in the previous case, though less of it will be required.

Where very small quantities of lime have been found most effectual, they have been given as part of compost heaps, of which the remaining and much larger portion is of any rich soil, peat, or swamp and pond mud, or wood's leaves or litter. This general plan is that of La Sarthe in France, before adverted to, and also general in Normandy, and in Belgium, and which Puvis, the author whose "Essay on Lime" furnishes the facts, deems the best mode of application. He says—"There is first made a bed of earth, mould, or turf, [peat,] of a foot or thereabout in thickness. The clods are chopped down, and then is spread over a layer of unslaked lime, of a hectolitre [2 7–8 bushels] for 20 cubic feet of earth. Upon this lime, there is placed another layer of earth, equal in thickness to the first, then a second layer of lime; and then the heap is finished by a third layer of earth." As soon as the lime is fully slaked, by the moisture of the earth, "the heap is cut down, and well mixed; and this operation is repeated afterwards before using the manure, which is delayed as long as possible, because the power of the effect on the soil is increased with the age of the

compost, and especially if it has been made with earth containing much vegetable mould."* It may not be unnecessary to state that there should not any animal excrement be permitted to enter the compost heap, as such highly putrescent matter would be damaged by the contact and decomposing action of caustic lime.

I have had no personal or experimental knowlege of the effects of this practice; nor had I heard of any one having followed the directions of the French author and the recommendation of his translator until this year and in this State. When in Sumter I was informed that Mr. Peter Mellett, a judicious planter not long since deceased, having read the article above quoted from, determined to try the plan. Though not far distant from the rich marl and marl-stone at and near Vance's ferry, it was not then known that there were the cheapest sources of supply; and knowing of no better mode, he thereafter bought northern lime in Charleston, at such price as it happened to bear whenever his cotton was wagoned to market, (generally from $1 25 to $1 50 the cask of about 3 bushels); and as return loads, the lime was thus brought to him by 90 miles land-carriage, including the expensive ferriage over the Santee. With it, he formed compost heaps, as above described, but of which the other materials were principally, if not entirely, of leaves and wood-land scrapings. He applied this to his cotton land for every crop, which was every year, in such quantities as gave only 2 1-2 bushels of lime to each acre. This course he continued, to such extent as his return loads of lime served for, until his death, 8 years after his commencement, and throughout he was well satisfied with his results, and the manifest and great improvement produced. The death of Mr. Mellett, and there being no person particularly acquainted with his experiments, prevented my obtaining more precise information; and perhaps even what is stated may be incorrect in the minor particulars. But whatever may be wanting in details, there is no doubt entertained among those persons residing in that neighborhood, of there having been very great improvement of both crop and land thereby produced, and of good profit made, even on this extravagant and unnecessary cost of lime. Col. James Richardson, who was acquainted with all these general facts, was so well satisfied with the results that he has followed the example to some extent, and is prepared to proceed; and though at unusual cost for lime, still at less than the preceding operations of his neighbor. He will procure marl-stone from across the river, and then wagon it 8 miles from the nearest accessible landing place to his plantation, there to be burnt and then mixed in compost heaps.

I should have been very far from recommending such small doses of lime, and for promising any appreciable effects from them; and still further from recommending the obtaining lime at such enormous cost, in either price or carriage. But the facts are the more interesting, on these very grounds, and much more so because of their having occurred in South Carolina, and where they may be examined into strictly, and their truth and value tested.

Whatever may have been the cost of this experiment of Mr. Mellett's, it is believed by some of his most intelligent and respectable neighbors that in

* See Puvis's "Essay on Lime," translated in Farmers' Register, vol. III, commencing page 359.

8 years he had thus raised land to the product of 1,000lbs. of seed cotton to the acre, which before was so excessively poor that it was supposed not capable of producing more than 100lbs. Even when admitting this reported fact, it may be objected, that it was not the lime, but the vegetable matter of the compost, which produced the much greater part of this wonderful increase. Unquestionably it was not the lime; for if it had been used in as small quantity alone, it would have produced no such benefit, and probably no perceptible effect in one year. But still it was the lime that enabled the vegetable part of the compost so to act and so to endure. For it is the general practice of the lower districts to apply vegetable compost, without lime, but with the addition of some rich animal admixture, and no such durability of effect, or extent of increase of crop, has been so produced. And such applications cease to act and are exhausted after one or two crops; and even though renewed (as is common on some lands,) every crop, never shows effects continually and greatly increasing for eight years, as did Mr. Mellett's compost. In my opinion, in his case the great benefit produced was neither by the lime nor the vegetable matter, as such; but by the new substance (probably *humate of lime*), formed by the chemical combination of the lime with a portion of the vegetable matter.

According to the French author above quoted, and also to English authority, experience has shown that the older the compost, the better it acts as manure. This is a strong practical proof of the correctness of my opinion just expressed. For a considerable length of time can give no more strength nor activity to either the lime or the vegetable matter; but it can, and it is necessary for that purpose, more effectually combine the two, and form a new manure better than either or both the combining materials.

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