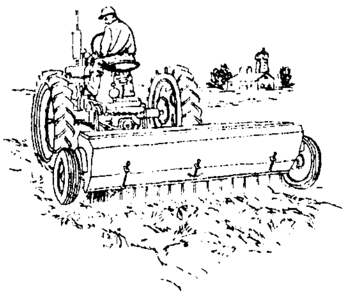

Plant Food Techniques Show Improvement

MAGNESIC MINERALS AND SOILS

A 4-Year Lysimeter Study of Their Interreactivities

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A 4-year lysimeter study was prompted by the possibility that directly incorporated serpentine, and olivine, might be an economic source of magnesium in forms available to plants. Through analyses of rain-water leachings of bicarbonate, magnesium, calcium, potassium, nitrate nitrogen, and sulfate sulfur from 1000-pound-per-acre inputs of magnesium oxide equivalence, it was established that the −100+200-mesh separates underwent slight decompositions, the −325-mesh materials suffered somewhat greater decompositions, and both silicates retarded the dissolution of the calcium and potassium of the native complexes. In contrast to their reactivities when mixed in superphosphate, the silicates proved decidedly less reactive than either magnesite or dolomite in the soils. Inputs of magnesium caused decreases in outgo of calcium. Limestone negated the chemical reactivites that resulted from single incorporations of the magnesic minerals. The silicates registered variable and uncertain effects upon nitrification and sulfofication, in contrast to the biological accelerations that were induced by dolomite and by limestone. Magnesium silicate materials cause an unbalancing of soil nutrients and do not afford a balanced supply of nutrient magnesium in unlimed soils, whereas the two silicates continue almost inert in limestoned soils.

THE IMPORTANCE OF MAGNESIUM as a plant nutrient is recognized universally, and several carriers have been utilized for inclusion in fertilizers and for direct incorporation in soils. After Garner and associates (*4*) had demonstrated that "sand drown" is caused by a paucity of soil magnesium, "low grade potash salts" and calcined kieserite were imported to supply water-soluble magnesium. That form now is being mined in the United States and marketed as the double salt of magnesium and potassium. But, for years dolomite was the most extensively used corrective for magnesium deficiencies in soils, through its inclusion in fertilizers and through its direct incorporation. Between 1920 and 1950, 7,750,000 tons of dolomite fines were used for mixings into fertilizers (*13*), and a much larger tonnage was used for soil liming; 12,000,000 tons of Knox dolomite fines were shipped from one operation in east Tennessee. In more recent years, the magnesium content of dolomite has been made decidedly more "available," through selective calcination of the rock to a product comprised of calcium carbonate and magnesium oxide (*10*).

The crude oxide of magnesium from sea water and hydrated dolomitic calcines also have been utilized for soil liming.

Consideration of the mineral silicates to supply nutrient magnesium in fertilizers, in soils, and to plants was stimulated through an authoritative report concerning extensive and easily accessible occurrences of the forsterite minerals in western North Carolina and in northern Georgia (*6*).

Serpentine has been used, in lieu of dolomite, in the conditioning of superphosphate in New Zealand (*1, 2*) and the Tennessee Valley Authority developed a process for the fusion of mixtures of olivine and rock phosphate to obtain a partially defluorinated product char-

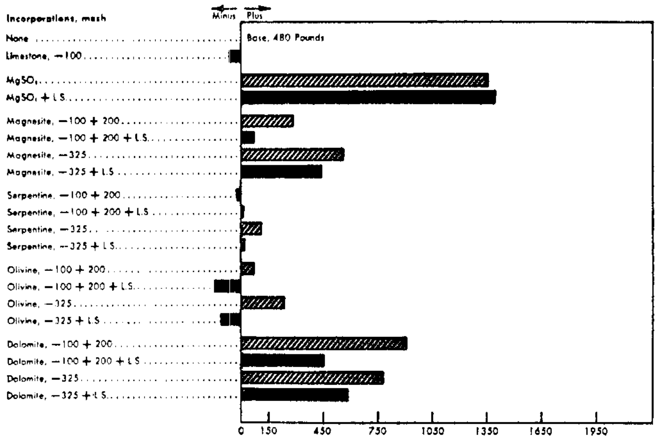

Figure 1. Magnesium carried from 1000-pound inputs of magnesia by 4-year rain-water drainages

From five carriers incorporated in Claiborne silt loam, with and without 2-ton inputs of 100-mesh limestone. Outgo in terms of $CaCO_3$ equivalence, pounds per 2,000,000 pounds of soil

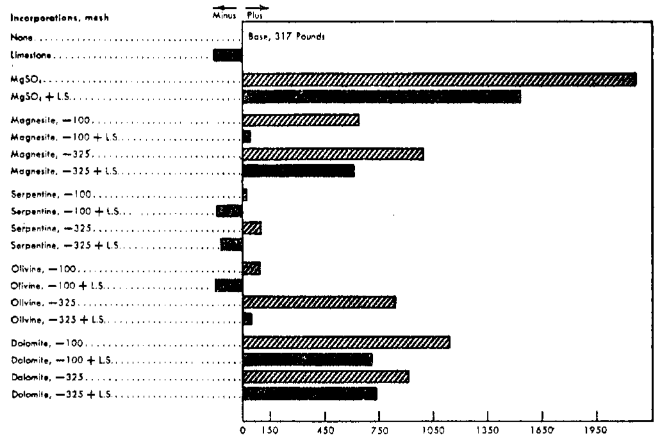

Figure 2. Magnesium carried from 1000-pound inputs of magnesia by 4-year rain-water drainages

From five carriers incorporated into Hartsells fine sandy loam, with and without 2-ton inputs of limestone. Outgo in terms of $CaCO_3$ equivalence, pounds per 2,000,000 pounds of soil

acterized by high phosphorus pentoxide "availability" (*15*). That process is being utilized in Japan to produce Thermophos, a calcium-magnesium phosphate product that has proved efficacious on the phosphorus-deficient acidic soils of that country (*7, 8*).

Serpentine and olivine undergo rapid and complete decomposition in their mixtures with moist superphosphate (*9*), and an analytical procedure was evolved for the determination of the resultant dimagnesium phosphate (*5*). In pot cultures (*11, 12*), however, the two mineral silicates were ineffective, although they had proved decidedly more decomposable than either dolomite or magnesite in mixtures with superphosphate (*9*). Because of this apparent contradiction, and because little was known as to the behavior of additive silicates in the soil, a lysimeter experiment was planned to ascertain what happens when representative magnesium silicate minerals are incorporated into soils.

Table I. Chemical Properties of Soils Used

Determinations[a]	*Claiborne Silt Loam Meq.*[b]	*Hartsells Fine Sandy Loam, Meq.*[b]
Exchange capacity at pH_7	11.4	12.2
Exchangeable Ca	4.5	1.2
Exchangeable Mg	1.1	0.3
Exchangeable H	5.8	10.7
Base saturation, %	49.1	12.3
pH	5.7	4.5

[a] Exchangeable Ca and Mg were by ammonium acetate extraction and leaching; exchangeable H was through replacement with 0.5 *M* neutral Ca acetate and titration of engendered acidity at pH 8.8; exchange capacity represents summation of values for Ca, Mg, and H.

[b] Per 100 grams of soil.

Experimental Work

The experimental outline stipulated that a magnesium oxide constant be supplied to two soils of distinctive type through incorporations of serpentine, olivine, magnesite, and dolomite, alone and with limestone—and that resultant reactivities be measured through titrative determinations of the bicarbonates, and of magnesium, calcium, potassium, nitrogen, and sulfur carried in the rain-water drainages.

Soils and Procedures The characteristics of the Claiborne silt loam and of the decidedly more acidic Hartsells fine sandy loam are registered through the analytical values given in Table I. Every soil placement was 100 pounds, moisture-free basis, and lay upon quartz filter beds in galvanized iron, asphaltum-coated 1/20,000-acre lysimeters (*14*). The placements of the untreated soils and the limestoned units were in duplicate to afford evidence as to experimental variations.

Each magnesic material and the dolomite supplied magnesium in equivalence to a 1000-pound input of magnesium oxide per 2,000,000 pounds of soil, moisture-free basis, and the limestone incorporations supplied calcium carbonate at the 4000-pound rate. The serpentine had a magnesium oxide content of 42%, and upon calcination acquired an x-ray pattern identical to that of the olivine, which contained 48% of magnesium oxide. Both silicate minerals were virtually devoid of calcium. The limestone contained 98.5% of calcium carbonate; the dolomite contained 51% of calcium carbonate and 37.5% of magnesium carbonate. The minerals were of two finenesses, −100 + 200-mesh separates and −325-mesh screenings. The terms "finer" and "coarser" are used in the text to connote separates of −100 +200-mesh and of −325-mesh, respectively.

All of the mineral additives were virtually devoid of potassium and sulfate. The equivalent incorporations of magnesium as the sulfate were intended as controls against outgo of magnesium solutes, should such develop from the magnesic minerals in the soils.

The rain-water drainages were collected periodically. Bicarbonate and nitrate contents were determined on every collection of leachings and a fraction of each collection was reserved in an annual composite for determinations of the outgo of magnesium, calcium, potassium, and sulfates. The findings from the periodic analyses and those from the 1056 analyses of the four annual composites were condensed into the totals of Tables II, III, and IV, which register the drainage from a 204-inch rainfall. The analytical methods used were those of the Association of Official Agricultural Chemists (*3*).

Composition of Rain-Water Leachings

Bicarbonate Outgo The stability of the serpentine and olivine separates in the Claiborne silt loam is indicated by the paucity of bicarbonates in the leachings from the two minerals in that soil. Those leachings indicated some decomposition of the finer magnesite separate, but they did not register substantial differences between the decompositions of finer and coarser separates of the two silicate minerals.

All of the incorporations of dolomite and limestone induced significant increases in bicarbonate outgo. In all comparisons that involved limestone and either a magnesic mineral or dolomite, the combination that included the finer mineral yielded the larger outgo of bicarbonate. The largest passages of bicarbonates were those from the jointly incorporated dolomite and limestone, which afforded maximal surface of calcium carbonate for the dissolvent action of the soil waters.

Bicarbonate outgo from the highly acidic Hartsells fine sandy loam was increased by all of the minerals and reflected appreciable reactivities between the additives and the acidoids of this soil. The passages of bicarbonates from the finer separates exceeded the passages from the coarser separates, and every joint incorporation of a magnesic mineral and limestone caused a bicarbonate outgo beyond the one from the mineral alone. Occurrences of bicarbonates in the leachings from the silicate minerals were from hydrolytic disintegrations, without a build-up of carbonate content in the soils, and were decidedly less than the occurrences of bicarbonates in the leachings from limestone and from dolomite.

Magnesium Outgo Magnesium outgo from the untreated soils of Table II comprised the washdowns from the atmosphere and solutes resultant from the hydrolysis of soil complexes. The leaching of magnesium from the native magnesic complexes was repressed by the incorporated limestone, and therefore each limestoned soil yielded an outgo of magnesium less than the outgo from the unlimed soil.

However, the leachings of magnesium from the input of the water-soluble sulfate were not diminished by the limestone supplements in the Claiborne silt loam. In that soil the incorporated silicates proved decidedly inactive, whereas the magnesite caused substantial increases in the amounts of magnesium leached from both soils, which is shown by the graphs of Figure 2. As notated, this relationship is opposite to the fact that the two silicate minerals proved decidedly more reactive than either magnesite or dolomite (*9*) in mixtures with adequately moistened superphosphate.

Although the leachings from the coarser particles of serpentine and of olivine did not show a significant increase in magnesium outgo from the two soils, appreciable increases were registered by the two 325-mesh separates. Although the effect of extreme fineness was reflected by the increases in outgo of magnesium from the 325-mesh separates of magnesite, serpentine, and olivine, that effect was either diminished or nullified wherever those separates were supplemented by limestone, as shown graphically for the Claiborne soil in Figure 1.

Magnesium outgo from the meager supplies native to the highly acidic Hartsells soil was diminished greatly by the incorporated limestone. Moreover, the outgo of magnesium from the jointly incorporated magnesium sulfate and limestone was 639 pounds less than the outgo from the sulfate alone, whereas the limestone did not induce a repression in the outgo of magnesium from its sulfate in the Claiborne soil, as is shown in Figure 2.

In every comparison for the Hartsells soil, the finer separate of each magnesic mineral yielded the larger release of magnesium to the leachings. The most significant increase in the outgo of magnesium from the incorporated silicates was the one of 718 pounds from the unsupplemented input of 325-mesh olivine.

Again, the effect of the limestone supplement was always a lessening in the outgo of magnesium from the added silicates, and from the magnesite. In this soil, as in the Claiborne soil, the limestone supplement served to enlarge the proportion of calcium substantially beyond the quantity supplied by the additive dolomite, and thereby lessened the outgo of magnesium below that from the unsupplemented dolomite.

In the comparisons between dolomite and the combination of dolomite and limestone, in both soils, limestone repressed the dissolving of the dolomite and thereby diminished the outgo of magnesium from the dolomite. In every case, annual outgo of magnesium from any of the five carriers was largest for the initial year, smallest for the fourth year, and fairly alike for the second and third years.

It seems obvious that serpentine and olivine imparted appreciable concentrations of magnesium solutes to the free soil waters of the Claiborne and Hartsells

Table II. Totals of Bicarbonates, Magnesium, and Calcium as Calcium Carbonate Equivalences

(In 4-year leachings from magnesium silicate and carbonate minerals in two soils)

Magnesic Material		Outgo as $CaCO_3$ Equivalences, Pounds per 2,000,000 Pounds of Soil									
		Claiborne Silt Loam					Hartsells Fine Sandy Loam				
		Bicarbonate	Magnesium		Calcium		Bicarbonate	Magnesium		Calcium	
Incorporation	Mesh[a]		Act.	Vari.[b]	Act.	Vari.[b]		Act.	Vari.[b]	Act.	Vari.[b]
None	..	257	485	..	917	..	71	317	..	821	..
Limestone	−100	452	427	−53	1642	727	300	143	−162	1598	747
$MgSO_4$	..	180	1875	1395	1217	302	136	2508	2203	750	−101
$MgSO_4$ + L.S.	−100	521	1902	1422	1727	812	285	1869	1564	2130	1279
Magnesite	−100+200	190	800	320	740	−175	185	961	656	501	−350
Magnesite	−325	375	1074	594	741	−174	268	1318	1013	311	−540
Magnesite + L.S.	−100+200	616	554	74	1618	703	314	348	43	1512	661
Magnesite + L.S.	−325	772	939	459	1668	753	426	936	631	1322	471
Serpentine	−100+200	226	473	−7	912	−3	129	332	27	792	−59
Serpentine	−325	239	597	117	1093	178	152	417	112	787	−64
Serpentine + L.S.	−100+200	500	483	3	1776	861	219	182	−123	1594	743
Serpentine + L.S.	−325	688	512	32	1714	799	256	202	−103	1677	826
Olivine	−100+200	167	551	71	987	72	91	404	99	809	−42
Olivine	−325	214	710	230	921	6	194	1023	718	444	−407
Olivine + L.S.	−100+200	467	335	−145	1351	436	252	166	−136	1598	747
Olivine + L.S.	−325	510	365	−115	1203	288	260	357	52	1542	691
Dolomite	−100+200	750	1424	944	1292	377	273	1313	1008	872	21
Dolomite	−325	641	1281	801	1175	260	282	1238	933	844	−7
Dolomite + L.S.	−100+200	1374	947	467	2069	1154	481	1025	720	1765	914
Dolomite + L.S.	−325	1493	1069	589	2045	1130	593	1056	751	1731	880
Limestone	−100	461	402	−78	1496	581	175	144	−161	1703	852
None		180	475	..	913	..	67	293	..	881	..

[a] Minerals other than limestone, which was constant at 100 mesh.
[b] Variation from mean for controls.

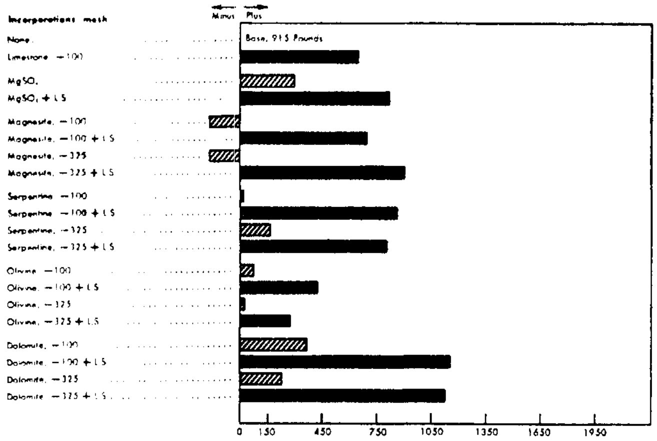

Figure 3. Calcium carried by 4-year rain-water drainages

From Claiborne silt loam that received a uniform 1000-pound input of MgO from five carriers, with and without 2-ton inputs of limestone. Outgo in terms of $CaCO_3$, pounds per 2,000,000 pounds of soil

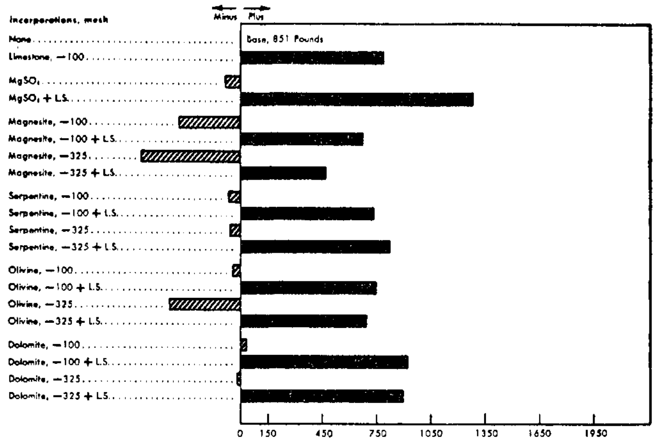

Figure 4. Calcium carried by 4-year rain-water drainages

From Hartsells fine sandy loam that received uniform 1000-pound input of MgO from five carriers, with and without 2-ton inputs of limestone. Outgo in terms of $CaCO_3$, pounds per 2,000,000 pounds of soil

soils only when the incorporations of the two minerals were in pulverized state and that jointly incorporated limestone served to stabilize the incorporated magnesic minerals, as is shown in Table II and in Figures 1 and 2.

Calcium Outgo The passage of calcium from the Claiborne soil (Table II) was increased 33% through replacement by the magnesium of the added magnesium sulfate. The indicated replacement represents 65% of the sulfate's capacity to effect base exchange. The magnesite separates caused substantial decreases in the leaching of calcium from supplies native to both soils, but the repressions were negated where the magnesite was supplemented by limestone. The one significant indication that the magnesium of the silicates may have effected replacement of the calcium in the Claiborne soil was registered by the 325-mesh serpentine, as shown in Figure 3. Although the calcim outgo from the combinations of serpentine and limestone exceeded the outgo from the limestone alone, the leachings of calcium from the corresponding combinations of olivine and limestone were considerably less than those from the limestone.

The leachings of calcium from the dolomite separates in the Claiborne soil were greater than those from the magnesic minerals. The passages of calcium from the combinations of "Knox" dolomite and limestone were much larger than the passage from any of the sixteen separate inputs of the solid magnesic and dolomitic materials, and larger also than the outgo from the limestone controls. The enhancements in the outgo of calcium from the dolomite were from an incorporation that supplied not only the 1000-pound input of magnesium oxide, but also a 2500-pound concomitant input of calcium carbonate. In the combination of dolomite and limestone, however, the 4000-pound supplement of limestone raised the calcium carbonate input to approximately 9000 pounds, or almost twice the amount of that carbonate in the dolomite incorporation. Consequently, the outgo of calcium from the combination of dolomite and limestone was substantially greater than the leachings of calcium from the 4000-pound input of its carbonate in the limestone control. Apparently, the neutral solute of magnesium was not repressive upon outgo of neutral solutes of calcium, when the two solutes were engendered together in the soil.

Calcium outgo from the Hartsells soil (Table II) was not increased by the incorporated magnesium sulfate, but the combination of sulfate and limestone gave a calcium outgo that was 500 pounds greater than the corresponding outgo from the limestone controls. Substantial decreases in the outgo of calcium from this highly acidic soil were induced by the magnesite separates, as shown in Figure 4. Moreover, the leachings of calcium from the combinations of magnesite and limestone were lessened below

Table III. Effects of Magnesic Materials upon Potassium Outgo in 4-Year Leachings from Complexes Native to Two Soils

(Pounds of K per 2,000,000 pounds of soil)

Claiborne Silt Loam				*Hartsells Fine Sandy Loam*		
Magnesic Materials[a]						
Incorporation	*Mesh*	*K outgo, lb.*	*Vari.*	*Mesh*	*K outgo, lb.*	*Vari.*
None, mean	. .	127	. .	. .	89	. .
Limestone, mean	−100[b]	96	−31	−100[a]	39	−50
$MgSO_4$	. .	127	0	. .	91	2
$MgSO_4$ + L.S.	. .	74	−53	. .	47	−42
Magnesite	−100+200	114	−13	−100+200	72	−17
Magnesite	−325	93	−34	−325	52	−37
Magnesite + L.S.	−100+200	86	−41	−100+200	38	−51
Magnesite + L.S.	−325	91	−36	−325	36	−53
Serpentine	−100+200	110	−17	−100+200	92	3
Serpentine	−325	120	−7	−325	94	5
Serpentine + L.S.	−100+200	89	−38	−100+200	42	−47
Serpentine + L.S.	−325	87	−40	−325	45	−44
Olivine	−100+200	144	17	−100+200	100	11
Olivine	−325	136	9	−325	66	−34
Olivine + L.S.	−100+200	95	−32	−100+200	42	−47
Olivine + L.S.	−325	86	−41	−325	36	−53
Dolomite	−100+200	110	−17	−100+200	30	−59
Dolomite	−325	92	−35	−325	29	−60
Dolomite + L.S.	−100+200	72	−55	−100+200	17	−72
Dolomite + L.S.	−325	93	−34	−325	24	−65

[a] All magnesic materials and dolomite provided 1000-pound inputs of MgO per 2,000,000 pounds of soil.
[b] All limestone incorporations were 100 mesh and were at 2-ton rate.

the outgo of calcium from the limestone alone.

The incorporated 325-mesh olivine exerted a substantial repression upon the passage of calcium from the supplies natural to the Hartsells soil. Since there was no apparent repression in the outgo of calcium from the combination of olivine and limestone, it appears that the separates of serpentine and olivine were stabilized by the limestone.

The two dolomite separates caused virtually no increase in the outgo of calcium from this highly acidic soil, in contrast to the considerable enhancements in outgo of calcium from the corresponding dolomite separates in the less acidic Claiborne silt loam. Again, however, the leachings of calcium from the larger quantity of calcium carbonate (9000 pounds) in the combinations of limestone and dolomite exceeded the outgo of calcium from the 4000 pounds of calcium carbonate in each limestone control.

Potassium Outgo The leachings of potassium are reported as averages in Table III and are compared graphically in Figure 5. Applied alone, the 2986-pound input of magnesium sulfate did not affect the quantities of potassium that passed from the two soils, even in the initial year, in which the leachings from the Claiborne and Hartsells soil gave respective recoveries of 83 and 77% of the additive sulfate of magnesium.

Potassium outgo was unaffected, or was diminished only slightly, in the twelve soil systems that contained incorporations of magnesite, serpentine, or olivine. But outgo of potassium was lessened substantially in the twelve corresponding systems in which the incorporations of the solid magnesic materials were supplemented through inputs of limestone. Incorporated singly and jointly with magnesium sulfate, with magnesite, and with the two silicate minerals, limestone lessened the outgo of potassium. In four systems, dolomite caused decreases in potassium outgo and still further decreases resulted from its joint input with limestone.

Apparently, the substantial inputs of the magnesic minerals served as protectives to lessen the capacity of the soil waters to effect hydrolytic decomposition of native potassic minerals and complexes. In general, the finer separate of each magnesic material effected the greater repression in potassium outgo from both soils.

Outgo of Nitrogen from Both Soils The nitrogen leachings given in Table IV were as nitrates. In seven cases, the inputs of the magnesic materials repressed nitrogen outgo below that from the untreated Claiborne soil. In the other seven cases, no increase in nitrogen outgo was rated as significant, and the single significant enhancement in nitrate outgo was from the dolomited soil.

Because the additive silicates did not cause significant increases in nitrate outgo from the two soils, it is obvious that they did not promote nitrification in these two soils under fallow. The only substantial enhancements in nitrate outgo from the Hartsells soil were those induced by the combinations of dolomite and limestone.

Sulfate Outgo from Both Soils Although additive sulfate passed from the Claiborne and Hartsells soils rapidly, the recoveries were not complete (Table IV). Recovery of sulfate from the magnesium sulfate in Claiborne soil was 55% of the input, against a 61% recovery from the combination of the sulfate and limestone. The corresponding recoveries from the Hartsells soil were 73% from magnesium sulfate alone and 83% from the combination of sulfate and limestone. Increase in sulfate recovery occurred wherever limestone and dolomite were incorporated, either singly or jointly. The four magnesite inputs caused increases in sulfate leachings from both soils, the larger increases being caused by the 325-mesh material. Again, the influence of the limestone on both soils is shown through the still larger passages of sulfate from the four units that received both magnesite and limestone.

The mineral silicates of magnesium induced small increases, if any, in formation and outgo of sulfate, whereas limestone and dolomite stimulated sulfofication and caused substantial enhancements in the leaching of sulfates from both soils.

Because the findings from nitrate

Table IV. Effects of Incorporated Magnesic Materials upon Outgo of Nitrate Nitrogen and Sulfur in 4-Year Leachings from Two Soils

(Pounds per 2,000,000 pounds of soil)

Magnesic Material		Claiborne Silt Loam				Hartsells Fine Sandy Loam			
		Nitrogen		SO_3		Nitrogen		SO_3	
Incorporation	Mesh	Act[a].	Vari.[b]	Act.	Vari.[b]	Act.	Vari.[b]	Act.	Vari.[b]
None	..	238	..	366	..	237	..	293	..
Limestone	−100	259	4	525	130	266	35	508	223
$MgSO_4$	..	195	−60	1683	1317	225	−6	2073	1760
$MgSO_4$ + L.S.	−100	238	−17	1829	1463	249	18	2304	1991
Magnesite	−100+200	290	35	437	65	217	−14	455	142
Magnesite	−325	229	−26	492	120	118	−113	504	191
Magnesite + L.S.	−100+200	215	−40	570	198	263	32	572	259
Magnesite + L.S.	−325	330	75	578	206	284	53	613	300
Serpentine	−100+200	226	−29	387	15	240	9	343	30
Serpentine	−325	323	68	409	37	243	12	368	55
Serpentine + L.S.	−100+200	316	61	558	186	248	17	553	140
Serpentine + L.S.	−325	265	10	539	167	294	63	537	224
Olivine	−100+200	308	53	380	8	228	−3	371	58
Olivine	−325	285	30	419	47	210	−21	427	114
Olivine + L.S.	−100+200	204	−51	473	101	249	18	549	236
Olivine + L.S.	−325	165	−90	424	52	268	37	566	253
Dolomite	−100+200	324	169	575	203	278	47	599	286
Dolomite	−325	305	50	592	220	283	52	595	282
Dolomite + L.S.	−100+200	273	18	532	160	373	142	659	346
Dolomite + L.S.	−325	272	17	559	187	361	130	662	349
Limestone	−100	248	7	478	106	299	68	553	240
None	..	271	..	378	..	224	..	322	..

[a] Minerals other than limestone, which was constant at 100 mesh.
[b] Variation, plus or minus, from mean for respective controls.

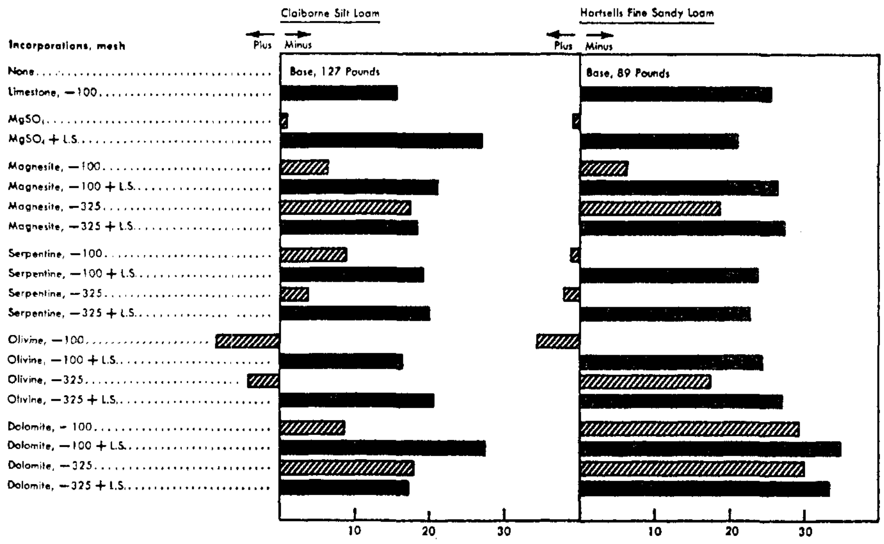

Figure 5. Potassium outgo in 4-year rain-water drainages

Form two soils that received 1000-pound incorporations of MgO in five forms, with and without 2 tons of limestone. Outgo in terms of K_2O, pounds per acre

leachings did not indicate intensive biological activation in the two soils, the effects of the unsupplemented inputs of magnesite and of dolomite upon outgo of sulfate may be related to the fact that the liming of the soils overcame tendency for the retention of the sulfate ion against rain-water leachings. The Hartsells soil possesses a distinctive capacity to retain additive sulfate against aqueous extractions and rain-water leaching. That capacity is diminished greatly through incorporations of liming materials. Hence, the increases in sulfate outgo that result from inputs of limestone and of dolomite are deemed attributable jointly to stimulated sulfofication and to a lessened tendency of the treated soils to retain sulfates against the leaching action of the drainage waters.

The foregoing observations are applicable also to the smaller leachings of sulfate from seven of the eight serpentine systems and from the eight olivine systems in contrast to the greatly enhanced outgo of sulfate from the eight units that received both magnesium silicates and limestone.

Dolomite induced substantial increases in sulfate leachings from both soils. The combination of dolomite and limestone induced large increases in the first-year leachings of sulfate and in the totals from the Hartsells soil, but the sulfate outgo from the dolomited and limestoned Claiborne soil decreased markedly in the fourth year, and this was reflected in the 4-year totals.

Carbonate Residues

In parallel studies, the final pH of the untreated Claiborne soil varied between 5.4 and 5.6, and Hartsells soil showed variations between 4.8 and 5.3. The mineral silicates did not induce determinable increases in solid phase carbonates. A year after incorporation, the 4000-pound-per-acre input of limestone had elevated the pH of the Claiborne soil to 6.7 and that of the Hartsells soil to 6.0. The 9000-pound incorporation of calcium carbonate (the equivalent of the combined additives of limestone and dolomite) imparted pH 6.8 to the Hartsells soil and 7.6 to the Claiborne. The Claiborne and Hartsells soils had respective capacities to effect decompositions of 8500 pounds and 18,000 pounds of calcium carbonate per 2,000,000 pounds of soil. Consequently, at the end of the 4-year experiment there was only a slight residue of limestone in the limestoned Claiborne soil and none in the limestoned Hartsells soil.

Summary

Serpentine, olivine, magnesite, and dolomite, with and without limestone, were compared in a 4-year lysimeter experiment, in which the inputs per acre basis were 1000 pounds of magnesium oxide and 4000 pounds of calcium carbonate in Claiborne silt loam and in Hartsells fine sandy loam. The decompositions of the incorporated solids were measured through determinations of bicarbonates, magnesium, calcium, potassium, nitrate, and sulfate carried by the rain-water drainage.

Magnesium outgo from both soils was increased by magnesite, slightly by the $-100+200$-mesh silicates, more so by their -325-mesh separates, and still further by dolomite. In all 16 comparisons, the jointly incorporated limestone caused lessened leachings of magnesium from the incorporations of magnesic and dolomitic materials. Calcium outgo was lessened by the magnesic minerals, increased by dolomite in Claiborne soil, and increased by every limestone supplement in both soils. Potassium outgo was lessened by every magnesic material, with and without limestone. After 4 years there were no carbonate residues in the systems that had received the magnesic materials, alone or with either limestone or dolomite.

The silicates caused increased nitrification in some cases, but not in others, and the biological effects of the limestone supplements were also variable. Sulfate outgo from both soils was increased by all of the magnesic materials, and by dolomite, and still further by the supplemental limestone.

The -325-mesh silicates, serpentine and olivine, proved decidedly less decomposable than either magnesite or dolomite in two distinctive acidic soils, under fallow, and the incorporated silicates gave no promise as effective carriers of nutrient magnesium to soils.

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