EUROSLAG Technical Leaflet No. 3

# Fertilisers from Blast Furnace and Steel Slags

## Silicate liming materials

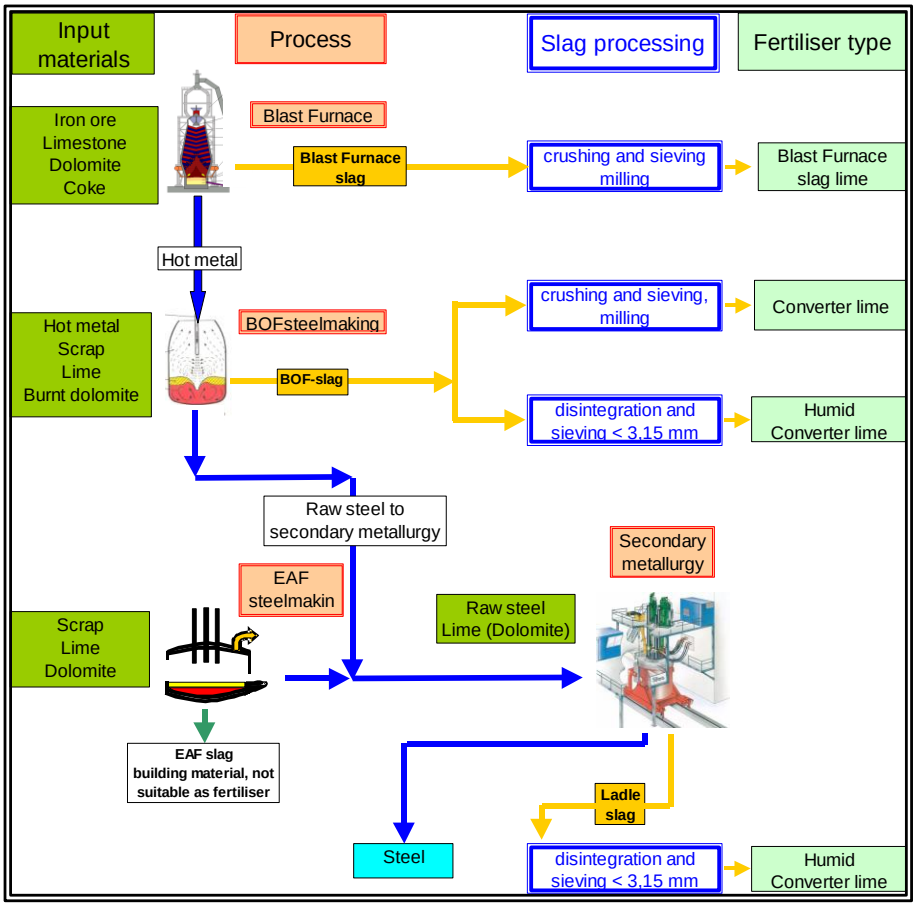
**are produced from blast furnace, converter or ladle slags. Careful selection and processing of appropriate slag qualities ensure an effective activity in the soil. Application of silicate liming materials neutralises soil acidity and supplies the soil with plant nutrients.**

## Origin

**Blast furnace slag** is generated during hot metal production, where iron ores are reduced with coke at elevated temperatures. The slag is formed by melting the gangue of the ore, coke ashes and additions to reduce the melting temperature of the slag and to fit the composition due to its further use.

The slag runs out of the blast furnace at temperatures above 1500°C. According to its further use, the slag is either cooled rapidly into a glassy material or air cooled into a crystalline rock-like-material.

**Converter slag** is generated in the Basic Oxygen Furnace (BOF) Steelmaking process by refining hot metal with oxygen. Considerable amounts of scrap are added to control the temperature of the reaction. For the metal-lurgical processing of the melt a slag is necessary, which is formed by addition of lime and/or dolomite, mainly. The raw steel and the slag are tapped into separate ladles at temperatures typically above 1600°C.




The slag is poured into a slag yard and air cooled into a rock-like crystalline material.

To protect the steel against reoxidation during further secondary metallurgical treatment, the liquid steel is covered by a slag, mainly generated by the addition of lime and dolomite. After steel casting, the so called **ladle slag** is poured into separate slag pits. Due to its mineral composition, Fig. 2, it consists mainly of calcium-silicates, some free lime and free MgO. The slag disintegrates during air cooling into a fine powder, suitable as fertilisers.

***Fig. 1: Production of fertilisers from Blast Furnace and Steel Slags***

## Mineralogy

The history of origin and the mineral composition of slag is very similar to those of volcanic rocks. The main minerals contain CaO, MgO, $SiO_2$, Mn and other valuable micro nutrients, Fig. 2.

Besides the physical treatment of the slags, their mineral composition has a decisive influence on the solubility and plant availability of the nutrients.

The special bond of silicate in the slag minerals results in favourable properties. The solubility of silicate from slags is often higher than from many other silicate containing soil improvers or rock powders, Fig. 3 and Fig. 4.

| Slag Type | Mineral composition | |
|---|---|---|
| Blast Furnace Slag | Akermanit | 2 CaO x MgO x 2 $SiO_2$ |
| | Gehlenite | 2 CaO x $Al_2O_3$ x $SiO_2$ |
| Converter Slag | Larnite | 2 CaO x $SiO_2$ |
| | Srebrodolskite | 2 CaO x $Fe_2O_3$ |
| | Magnesio-wustite | (Mg,Fe,Mn)O |
| | Free lime/Portlandite | CaO/$Ca(OH)_2$ |
| Secondary Metallurgical Slag (Ladle Slag) | Free lime/Portlandite | CaO/$Ca(OH)_2$ |
| | Periclase, Brucite | MgO, Mg(OH) |
| | Merwinite | 3 CaO x MgO x 2 SiO |
| | Dicalciumsilicate | 2 CaO x $SiO_2$ |

***Fig. 2: Typical minerals of different slags suitable as liming materials***

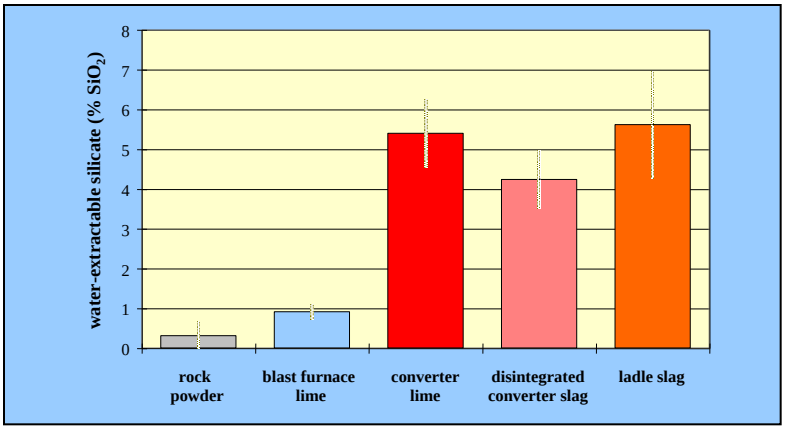



***Fig. 3: Water-extractable silicate content of silicate rock powders and liming materials [weigh-in/water relation: 1:3,4 (g/l) after 14-days of incubation]***

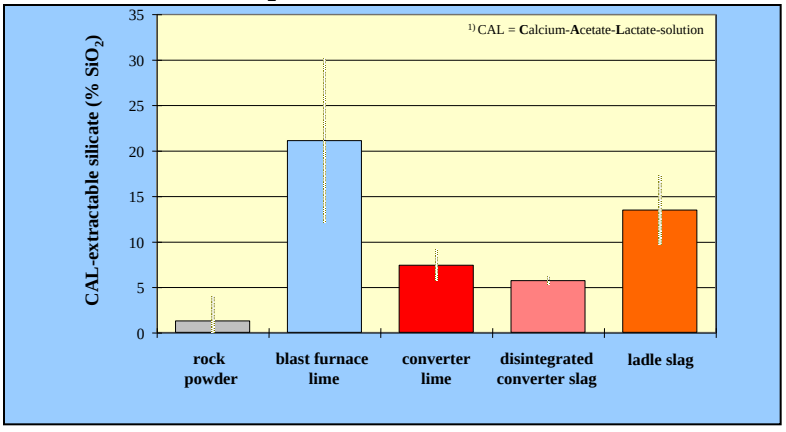



***Fig. 4: CAL-extractable silicate content of silicate rock powders and liming materials [Relation of weigh-in/CAL-solution: ca. 1 : 13,5 (g/l)]***

## Nutrient Elements

Silicate liming materials contain elements with useful properties for plant nutrition and soil qualitiy, Fig. 5.

The basicity of the calcium and magnesium compounds in the slags improves soil pH. Both elements also serve as plant nutrients and stabilisers for soil aggregates. Magnesium in slags especially in blast furnace slag has a better solubility than that of magnesium carbonate in limestone and dolo-mite. Silicate has beneficial effects on plant health, phosphate avail-ability and soil structure. The content of trace elements like manganese, copper, zinc, boron or cobalt satisfies both plant and animal demands [1,2].

| Liming Material [3, 4] | Blast Furnace lime granulated BF lime | | Converter Lime milled | Converter Lime disintegrated * |
|---|---|---|---|---|
| **Main nutrients in %** | | | | |
| Neutralising value [5] (CaO + MgO) | ~ 47 | | 50 | 41 - 50 |
| of that MgO | 7- 10 | | 2 - 3 | 3 – 5** |
| $P_2O_5$ soluble in citric acid | -- | | 1 – 2 | 1 - 2 |
| Silicate ($SiO_2$) | ~ 32 | | ~ 12 | ~ 12 |
| Manganese (Mn) | 0,5 - 1 | | 2 – 3 | 2 - 3 |
| **Micronutrients in mg/kg = ppm** | | | | |
| Copper (Cu) | 2 – 10 | | 5 – 40 | 5 – 40 |
| Boron (B) | 4 – 30 | | 10 – 30 | 10 – 30 |
| Zinc (Zn) | 3 – 166 | | 10 – 140 | 10 – 140 |
| Cobalt (Co) | 1 – 3 | | 2 – 5 | 2 - 5 |
| Molybdenum (Mo) | 1 – 5 | | 8 – 10 | 8 – 10 |
| **Other properties** | | | | |
| Bulk density in t/m³ | Ground 1,30 | Granulated 1,00 | 1,00 | 1,00 |
| Repose angle | 20° | 30° | 30° | 30° |
| * including Ladle Slag | | | | |

***Fig. 5: Properties of Blast Furnace- and Converter Lime***

**Health & Safety Information:**
**CAS: 65996-69-2; EINECS: 266-002-0; EU Safety Data Sheets: 404**
**CAS: 91722-09-7; EINECS: 294-409-3; EU Safety Data Sheets: 406, 407, 409**
**CAS: 65996-71-6; EINECS: 266-004-1; EU Safety Data Sheets: 413**

**References**:

[1] Rex, M.: Blastfurnace and steel slags as liming materials for sustainable agricultural production. EUROSLAG publication No. 1, pp. 137-149

[2] Rex, M. Environmental aspects of the use of iron and steel slags as agricultural lime. EUROSLAG publication No. 2, pp. 137-150

[3] European Standard EN 14069: Liming Materials - Description and minimum requirements (2004)

[4] European Standard EN 12944-3: Fertilizers and liming materials - Vocabulary - Part 3: Terms relating to liming materials (2001)

[5] European Standard EN 12945: Liming Materials - Determination of neutralizing value - Titrimetric methods (2002)

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## Fertilising Properties

**Blast Furnace Lime** has a mild effect on soil pH. Therefore it is especially recommended for use on humus, sandy and peat soils. The high silicate content and magnesium which is readily available to plants promote yields and plant qualities additionally.

**Converter Lime** from BOF slag as well as from ladle slag from the production of non-alloyed steel has a high neutralising value with prompt and sustainable effects on soil pH. Converter Lime is suitable for all kinds of soils. The soluble silicate content and its reactivity increase the phosphate mobility in the soil and improves the efficiency of phosphate fertilisation.

**The soluble silicate content in both Blast Furnace Lime and Converter Lime, improves soil structure as well as plant health.**

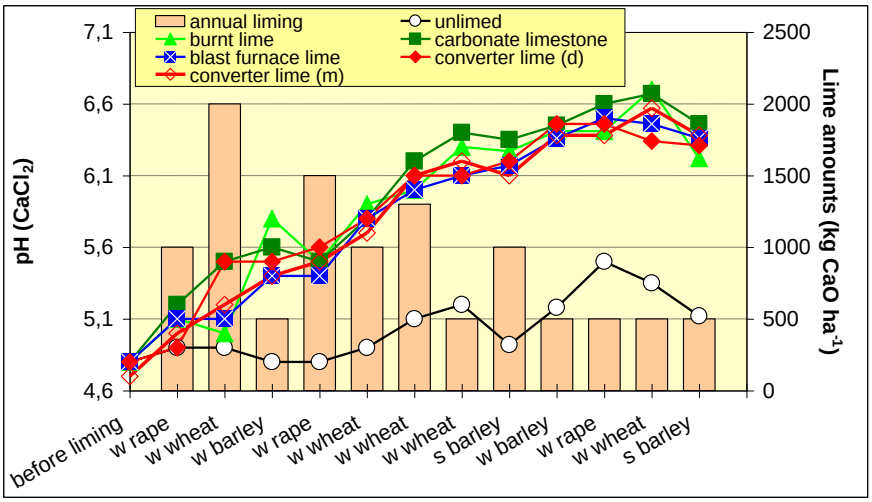


*Fig. 6: pH-effects of different liming materials in the soil of a long-term field experiment (1994-2004)*

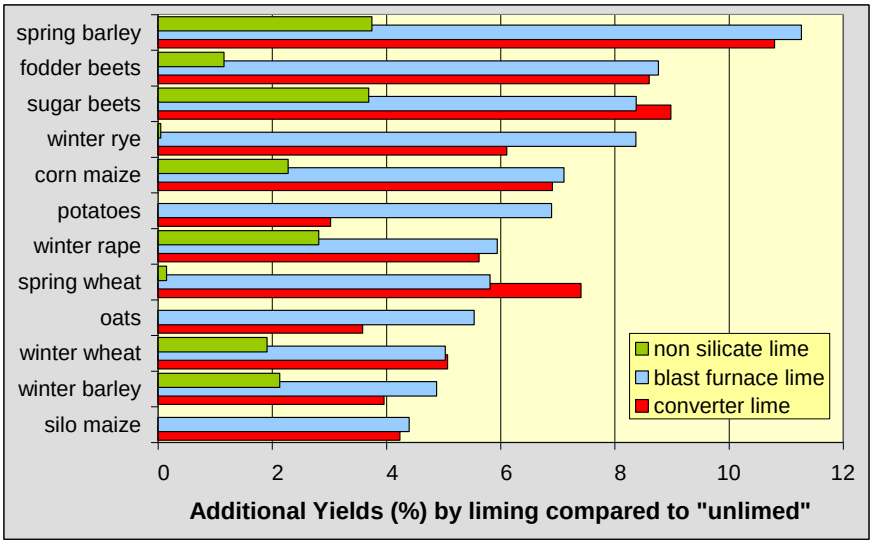


*Fig. 7: Mean relative additional yields by liming of different crops with silicate and non silicate liming materials in long-term field experiments on 34 different sites*


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