

GEORGIUS AGRICOLA  
DE RE METALLICA

TRANSLATED FROM THE FIRST LATIN EDITION OF 1556

with

Biographical Introduction, Annotations and Appendices upon  
the Development of Mining Methods, Metallurgical  
Processes, Geology, Mineralogy & Mining Law  
from the earliest times to the 16th Century

BY

HERBERT CLARK HOOVER

A. B. Stanford University, Member American Institute of Mining Engineers,  
Mining and Metallurgical Society of America, Société des Ingénieurs  
Civils de France, American Institute of Civil Engineers,  
Fellow Royal Geographical Society, etc., etc.

AND

LOU HENRY HOOVER

A. B. Stanford University, Member American Association for the  
Advancement of Science, The National Geographical Society,  
Royal Scottish Geographical Society, etc., etc.

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Bismuth<sup>59</sup> ore, free from every kind of silver, is smelted by various methods. First a small pit is dug in the dry ground; into this pulverised charcoal is thrown and tamped in, and then it is dried with burning charcoal. Afterward, thick dry pieces of beech wood are placed over the pit, and the bismuth ore is thrown on it. As soon as the kindled wood burns, the heated ore drips with bismuth, which runs down into the pit, from which when cooled the cakes are removed. Because pieces of burnt wood, or often charcoal and occasionally slag, drop into the bismuth which collects in the pit, and make it impure, it is put back into another kind of crucible to be melted, so that pure cakes may be made. There are some who, bearing these things in mind, dig a pit on a sloping place and below it put a forehearth, into which the bismuth continually flows, and thus remains clean; then they take it out with ladles and pour it into iron pans lined inside with lute, and make cakes of it. They cover such pits with flat stones, whose joints are besmeared with a lute of mixed dust and crushed charcoal, lest the joints should absorb the molten bismuth. Another method is to put the ore in troughs made of fir-wood and placed on sloping ground; they place small firewood over it, kindling it when a gentle wind blows, and thus the ore is heated. In this manner the bismuth melts and runs down from the troughs into a pit below, while there remains slag, or stones, which are of a yellow colour, as is also the wood laid across the pit. These are also sold.

"through." Pliny (XXXIII, 41): "There has been discovered a way of extracting *hydrargyros* from the inferior *minium* as a substitute for quicksilver, as mentioned. There are two methods: either by pounding *minium* and vinegar in a brass mortar with a brass pestle, or else by putting *minium* into a flat earthen dish covered with a lid, well luted with potter's clay. This is set in an iron pan and a fire is then lighted under the pan, and continually blown by a bellows. The perspiration collects on the lid and is wiped off and is like silver in colour and as liquid as water." Pliny is somewhat confused over the *minium*—or the text is corrupt, for this should be the genuine *minium* of Roman times. The methods of condensation on the leaves of branches placed in a chamber, of condensing in ashes placed over the mouth of the lower pot, and of distilling in a retort, are referred to by Biringuccio (A.D. 1540), but with no detail.

<sup>59</sup>Most of these methods depend upon simple liqutation of native bismuth. The sulphides, oxides, etc., could not be obtained without fusing in a furnace with appropriate de-sulphurizing or reducing agents, to which Agricola dimly refers. In *Bermannus* (p. 439), he says: "*Bermannus*.—I will show you another kind of mineral which is numbered amongst metals, but appears to me to have been unknown to the Ancients; we call it *bisemutum*. *Nævius*.—Then in your opinion there are more kinds of metals than the seven commonly believed? *Bermannus*.—More, I consider; for this which just now I said we called *bisemutum*, cannot correctly be called *plumbum candidum* (tin) nor *nigrum* (lead), but is different from both, and is a third one. *Plumbum candidum* is whiter and *plumbum nigrum* is darker, as you see. *Nævius*.—We see that this is of the colour of *galena*. *Ancon*.—How then can *bisemutum*, as you call it, be distinguished from *galena*? *Bermannus*.—Easily; when you take it in your hands it stains them with black unless it is quite hard. The hard kind is not friable like *galena*, but can be cut. It is blacker than the kind of crude silver which we say is almost the colour of lead, and thus is different from both. Indeed, it not rarely contains some silver. It generally shows that there is silver beneath the place where it is found, and because of this our miners are accustomed to call it the 'roof of silver.' They are wont to roast this mineral, and from the better part they make metal; from the poorer part they make a pigment of a kind not to be despised." This pigment was cobalt blue (see note on p. 112), indicating a considerable confusion of these minerals. This quotation is the first description of bismuth, and the above text the first description of bismuth treatment. There is, however, bare mention of the mineral earlier, in the following single line from the *Probierebüchlein* (p. 1): "Jupiter (controls) the ores of tin and *wismundt*." And it is noted in the *Nidliche Bergbüchlein* in association with silver (see Appendix B).