HALO EFFECT and related ground oddities

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Halo Effect

There are lots of reports by detectorists of "halo effect". The story is usually that a buried object (for instance in a test garden) became more detectable the longer it was in the ground; or, that a long-buried object was detected at a depth beyond what would have been expected. The popular theory is that corrosion products create a conductive "halo" around the metal object, increasing its effective size. Here's my take on the subject.

Soil disturbance I believe that many reports of "halo effect" are actually a misinterpretation of soil disturbance. When an object is buried, the act of digging and refilling the hole creates a localized soil anomaly which causes the detected signal to either add to or subtract from the signal from the metal object. What actually happens depends on the kind of soil and the details of how the detector processes signals, but most often the detectability of the target is reduced. Over time the disturbed soil settles and becomes mixed with surrounding soil by earthworm activity etc. such that the anomaly is gradually erased.

Gold Gold doesn't corrode. Most detectorists say that they have observed that gold exhibits no halo effect. In the case of natural gold, it is often found in an accumulation of magnetite, which may either increase or decrease detectability depending on circumstances, but most often it will decrease detectability. The effect of magnetite, which is disturbed upon removal of the gold from its natural setting, could lead a detectorist to believe they've observed a halo effect when in fact there was none.

Iron Iron does corrode. This reduces the amount of metallic iron, which reduces the signal produced by the iron target. However, in many soils, the corrosion products create a ring of high magnetic susceptibility rust particles surrounding the object, and as the searchcoil sweeps over the object, the rust particles bounce the signal around. The way signals are processed in most modern machines, the bounce from the rust particles boosts the signal from the conductive metal at the center of the rusted mass, raising its apparent conductivity making it harder to discriminate out. Detectorists are often puzzled that when they pull the iron target out of the ground and air test it, it seems a rather weak target and discriminates out easily. What happened is that the rust anomaly stayed in the dirt.

Copper (including copper alloys such as brass and bronze) In alkaline soils, copper alloys are fairly stable, but in acid soils they corrode sometimes fairly rapidly especially in the presence of sulfur. The result is a green ring of corrosion products around the metal piece the mass of which is reduced by corrosion. There are many reports of presumed halo effect in relation to copper alloys, such an interpretation being encouraged by the obviousness of the corrosion halo.

But there's this little problem: the electrical conductivity of the corrosion halo is very low compared to metal. Therefore we need other interpretations. Interpretation #1: the object in question was a high-conductivity coin, for example a wheat penny. Corrosion makes it thinner, increasing its effective resistance. Although the total signal is weakened, the resistive component of the signal which is primarily responsible for detection of metal objects is actually increased. Interpretation #2: maybe the chemical corrosion processes also change the iron chemistry of the soil in the corrosion halo, either increasing or decreasing their magnetic susceptibility. This could theoretically impact detectability. ………Some experienced detectorists may say that these two theories are inadequate to explain what they have actually observed. And that may be true. These theories just happen to be the best ones I've got for now, they're not a final word on the subject.

Silver "Big picture" fairly similar to that of copper. In most soils, silver is much more resistant to corrosion than copper alloys. Corrosion products of silver may have higher electrical conductivity than those of copper, but still, for a given amount of silver the electrical conductivity of the corrosion products is far lower than that of silver in solid metal form.

"Clay Domes"

Many detectorists have encountered situations where a patch of ground sounded off like there was metal present, but the more they dug the weaker the signal got until the signal vanished, and it became obvious no metal was present.

In many cases, the patch of ground in question was a spot of clay. The best explanation is that the clay was more electrically conductive than the surrounding soil because of its greater water-holding and ion exchange capacity. When you break it up, you break up the electric current paths that made it detectable.

Didn't show up on weather radar

You're sweeping over the ground, you hear a sound like metal is present, you dig, and the signal disappears. No metal. And this time it's not identifiable as a "clay dome".

See cows anywhere? Remember the phrase "like a cow pissin' on a flat rock"? Well, it's not always on a flat rock. And it's electrically conductive.

Don't see cows anywhere? Coulda been your buddy hung a leak there.

In a livestock or agricultural setting, there can be spots where there was a salt block, or where fertilizer was dumped. You can't see it now, but the conductive mineral salts are still in the soil.

Deeper after a good rain?

In semiarid and desert areas, there is usually quite a bit of mineral salts in the soil. When they're dry, they're nonconductive, but when wet they become electrically conductive. Usually, the soil will get "noisy" and you'll lose depth. In a few cases the dropping of the ground balance point resulting from moisture will improve response to the highest conductivity targets.

Most reports of improved depth after a good rain come from wetter climates. I used to attribute this to easier digging, not to any electrical phenomenon, since soils of wetter climates usually have moderate to low conductivity whether wet or dry. However, the great drought of 2011 changed my mind. Just too many reports from detectorists from Texas to the Atlantic who have planted test gardens, and they noticed that the drier things got, the weaker the target signals got, and when it finally rained a good one the signals came back. Digging didn't have anything to do with it.

So, now I believe the effect is real. I'm aware of several theories which attempt to explain it, and I don't like any of 'em. So for now I just accept that it really does happen and I don't know why.

Deeper at night?

I've heard reports from gold detectorists working in desert areas (esp. Australia) that the ground is noisier during mid-day, but then tends to quiet down in the late afternoon. Some such reports may actually result from thunderstorm activity and not have anything to do with ground, but I think most detectorists would know the difference.

My tentative explanation is this: it's during the middle of the day when the temperature gradients in the ground are steepest, with temperature differences as great as 40 degrees F or more in a mere several inches vertically. The magnetic properties of iron minerals are temperature-sensitive, so your ability to get clean ground balance is impaired.

The effect isn't noticed much in non-desert climates because of vegetation cover and because of the high heat capacity of soil moisture.

<u>**Do targets move in the ground?**</u>

Yep, they can, and in some cases they can move a lot. Here's how.

<u>Swelling clays (vertisols)</u>: In some regions, the ground cracks open during the dry season. Soils which do this are called "vertisols". Anything that's on the surface can fall into the crack, and anything that's on the wall of the crack higher up can break off and fall deeper. Over the years, the constant addition of material to the bottoms of the cracks pushes the adjacent soil sideways and upward. Over hundreds of years this churns the soil such that there is no horizontal layering such as is seen in most other soils.

<u>Frost heaving (freeze-thaw)</u>: Freeze-thaw cycles in colder climates churn the soil, although usually not so much as to prevent horizontal layering. In addition, solid objects (stones, metal objects) have higher thermal conductivity than the surrounding soil and therefore during the cooling phase ice forms underneath them and pushes them up. That's why the job of clearing stones from fields in such climates is never done, freeze-thaw keeps pushing new ones up. I suppose that over thousands of years of clearing stones, there wouldn't be any left.

<u>Bioturbation:</u> Critters that live in the dirt move dirt around, and therefore targets are susceptible to being moved around as well. My favorite example was in a test garden of metal targets I'd planted in northern Arizona. One target was a standard carpentry nail 6 inches deep—close to the limit of detection in discrimination mode, and even in all metals mode since this was a very noisy basaltic soil. One day I came testing prototypes and couldn't find the nail. At first I suspected maybe a problem with the prototype or perhaps my technique, but I was getting the expected hits on the other targets and verified that indeed the nail was no longer there. So I started digging to find out what the heck had happened, and found that a gopher had tunneled through and had moved the nail about a foot out of the way. We all thought "Caddyshack" was a comedy, but maybe it was a documentary……

<u>Erosion and deposition:</u> These processes may not move buried objects horizontally, but they do change the depth. Of course if a target is shallow, it may be moved horizontally by erosion processes.

In some areas which were once agricultural but have reverted to hardwood forest, leaf litter and other organic material as well as soil brought to the surface through earthworm and other bioturbation can add depth to the soil surface fairly rapidly, as much as several inches in a century.

<u>Human activity such as plowing and digging:</u> You may not see those processes happening today, but they may have happened in the past. This is especially true of battlefield sites.

--Dave J.