

Gold Prospecting with a VLF Metal Detector

*Dave Johnson, Chief Designer
First Texas Products & Fisher Research Labs*

This book explains how to use a VLF metal detector for finding gold. The author has nearly 30 years' experience in the metal detector industry working for several different companies, and designed several of the most popular "gold machines" on the market. Although the product emphasis is on the machines currently "Made in El Paso", the features of competitors' machines are also discussed. This booklet is useful no matter what brand of metal detector you use. Subjects include:

Geological settings in which to do electronic gold prospecting. About gold. Electromagnetically active minerals in the soil and rocks. "Hot rocks".

Meteorites. Ground mineral anomalies. How VLF metal detectors work. VLF gold machine metal detectors in general. FTP-Fisher "made in El Paso" gold machines. Choosing the gold machine that's right for you.

Interpreting ground readout data. An overview of how ground balancing works. "Grab", "tracking", and manual balancing. Adjusting threshold and gain. Sweeping the searchcoil over the ground. Checking a target. Extracting a target from the ground. Dealing with trash metal and hot rocks. Air testing (demoing) a metal detector. Electrical interference. Digging tools. To hunt solo, or with a partner? Organizations. Government agencies. Print publications. FTP-Fisher websites and factory sponsored forums. Internet sites relating to gold prospecting with metal detectors. The Troy weight system. The price of gold. The gold machines "Made in El Paso".



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GOLD PROSPECTING WITH A VLF METAL DETECTOR

*Dave Johnson, Chief Designer
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This book exists in several different print, electronic, and Web editions, identified by file date and time of editing. For the most up-to-date information on our metal detector products, please check our websites, your local dealer, or the factory sales department.

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Introduction

Gold prospecting using a VLF gold machine - quick summary

Hillsides are the best areas for gold prospecting using a metal detector, because hillsides cannot be cleaned out by panning and dredging the way streams can. Also, gold on hillsides, not far from its source vein, tends to be larger, and hence more readily detected, than alluvial (placer) gold which tends to get pounded to pieces and worn away as it rolls along the streambed with gravel during floods.

Gold is valuable because it is a scarce commodity. Even in a good gold producing area, you will often spend an entire day without finding any gold. Meanwhile you will dig bits and pieces of other metal-- birdshot, shells and bullets from hunting and target practice, bits of rusted barbed wire, chips off shovels and other mining tools, rusted tin cans, etc. "Hot rocks" -- rocks containing concentrations of iron oxides that sound like metal when you pass over them -- are also a nuisance in many places where gold is found.

If you have gone many hours without finding gold and are wondering if there is something wrong with your metal detector or how you are using it, the most important clue is this: if you are digging tiny pieces of trash metal, then if you had swept over gold nuggets, you would have dug them too!

When something that sounds like gold has been detected, most of the time it's iron metal or a hot rock. Smart prospectors carry a strong magnet with them, and stick the magnet into the dirt where the detected object is. Iron will be drawn to the magnet, and hot rocks usually will be as well. Even if you pull iron metal or hot rocks out, always check again with the metal detector to see if there is gold (which of course won't be drawn to the magnet). A good magnet is what a gold prospector uses instead of "discrimination mode".

Most gold nuggets are very small, and are most often found in soil which is high in iron oxide minerals. Therefore serious gold prospecting requires a detector with high sensitivity and with true ground balanced motion all metals operation. Run the machine with the sensitivity high enough to hear some noise from ground minerals, and learn the language of the sounds you hear. Most prospectors prefer to use headphones unless consideration for safety (for instance rattlesnakes) rules them out. Move the searchcoil slowly and deliberately, carefully controlling its height above the ground to minimize noise from iron minerals in the soil. If you hear ground noise, your ground balance setting could be a bit off, so perform the ground balancing procedure again. In some areas the ground changes over very short distances and you'll have to pay close attention to ground balance.

Some “gold machines” display the amount of iron mineralization in the ground. In alluvial (placer) deposits, gold tends to be associated with iron minerals, particularly magnetite black sand. If you know this to be the case in the area you're working, you can maximize your gold recovery by concentrating your effort on areas where the display indicates higher amounts of iron mineralization.

Where do I go gold prospecting?

You probably already know which gold producing areas interest you. Some people prefer to prospect in the nearest gold producing district, whereas others like to take “gold tours” to places like Alaska and Australia which have some particularly good gold prospecting districts.

We've all heard the saying “gold is where you find it”. There are a few places where gold is, and the rest of the world where gold isn't. It's rare that a new “metal detectorable” goldfield is discovered. Even that discovery is usually the product of geophysical exploration, not someone getting lucky with a metal detector. Search where other people have found gold.

Don't do your gold prospecting in places you don't belong.



FISHER F75 *The Ultimate Detector*

- Double-D search coil
- Trigger-actuated FASTGRAB™ ground balance
- Double-filter discrimination modes for searching in trashy areas
- Magnetic mineralization bar graph read out
- Frequency shift for eliminating electrical interference and crosstalk
- Visual target ID by category & 0-99 indication, both discrimination & auto-tone modes
- Trigger-actuated target pinpointing with variable audio pitch
- Non-volatile memory saves settings
- Backlight
- Low operating cost - typically 40+ hours with 4-AA batteries
- Large LCD screen with target identification display
- Rain cover for control housing & battery housing available
- 13 kHz frequency— good for coin shooting, relic hunting, and gold prospecting



TEKNETICS T²

The Teknetics T² is a high performance multi purpose professional metal detector. It utilizes the latest advances in electronic technology, and its functional design represents the leading edge of engineering.

The T² is easier to learn than other comparable metal detectors. Its combination of light weight and balance provides comfort unmatched by any other detector in its price range. Its most popular uses include coin shooting, relic hunting, and gold prospecting.

- Large LCD Screen with Target Identification Display
- Intuitive User Interface
- Menu-Driven User Interface
- Menu Always Visible
- Trigger Actuated Target Pinpointing
- Double Filter Discrimination Modes For Searching In Trashy Areas
- Ground Cancellation
 - Trigger Actuated FASTGRAB™
 - Instant Ground Cancellation
- Manual Ground Cancellation Option
- Continuous Ground Monitor
 - Ground Mineralization Bar Graph Readout
- Waterproof 11-inch Open Frame Bi-Axial™ Search Coil
Great for Highly Mineralized Soils.
Renowned Target Separation Capability
Super Sensitive - Detect Coins to 15 Inches
- Low Operating Cost - More than 40 hrs with 4-AA Batteries

Learn how to recognize gold claims and do not search on them without first getting the claim owner's permission. In the USA, gold prospecting clubs/organizations usually own claims where members can go prospecting. In the Western USA there are areas where gold has been found in the past which are not presently under claim, located on BLM and National Forest land. Gold prospecting with a metal detector is usually permitted in these areas. To search on private or mining claim land, the owner may grant permission to search as long as you reassure the owner that you will not damage structures or leave unfilled holes, and will not hold the owner liable for accidents. If that is not sufficient, offer the owner to describe what you found and to map where you found it: this increases the owner's knowledge of the geological value of the property. You can also offer to collect and deliver to the owner any small metal trash and hot rocks you uncover rather than simply discarding these items on the site: this improves the usability of the site for further prospecting. Offering the owner a percentage of what you find is usually not a workable proposition because that requires more trust than most people have. Besides which, raw gold (unlike cash) is not something that can easily be split to a fixed percentage.

Geology, gold, and minerals

Geological settings in which to do “electronic gold prospecting”

Books on gold prospecting usually describe the occurrence of gold on and near the surface in the landscape as follows:

1. Higher up in the terrain, there's gold in exposed quartz veins (“reefs”).
2. Also higher up in the terrain, there's gold in the ground directly above quartz veins where the vein weathered in place.
3. Gold gradually moves downslope from its quartz vein source, carried by surface erosion and soil creep. So there's gold in that dirt.

4. Gold moving downslope eventually reaches a stream channel. There it is carried by water along with gravel and sand sediments, especially during floods.
5. Rising floods deposit sediment, including gold, above and alongside the stream channel. These sediments remain as terrace deposits when the floodwaters recede.

* * * *

This common “textbook” description is intended mostly to help the student learn to visualize geological processes. The actual geological situation on the ground in many mining regions is quite different. For instance, in many mining districts, gold is found in rock types other than quartz.

Here are some gold mining words in common use:

1. A “lode” is a highly localized zone of concentration of gold in rock.
2. Mining for gold in rock underground (by tunneling) or in rock exposed at the surface, is called “hardrock mining”.
3. Gold which is found in stream sediments (alluvium) is called “placer”, Spanish for “pleasure”. Digging it is almost pleasurable compared to the miserable work of hardrock mining. Until methods for working dry placer were developed, “placer” was synonymous with what we now call “wet placer”. The availability of fresh water made the hard work under the hot sun more tolerable.
4. “Wet placer” is placer in or near water, such that it can be worked by panning, sluicing, and other hydraulic methods.
5. “Dry placer” is placer where there is no water. Sometimes such placer is worked by hydraulic methods, using water hauled to the site.
6. “Desert placer” generally refers to dry placer deposited in desert alluvial fans and bajadas. It may be far from any present-day stream channels.



FISHER GOLD BUG II

The most sensitive gold hunting detector ever made

- Extreme Sensitivity to Small Gold Nuggets
- High Precision Dual-Control Ground Balance
- Iron Disc Mode for Iron & Hot Rock Rejection
- Deep Target Audio Boost
- Lightweight & Hip-Mountable
- Available with either a 6 1/2" or a 10" elliptical search coil
- Operating frequency: 71 kHz



TEKNETICS OMEGA 8000

Elevate The Possibilities

- Unique Intuitive Interface & Display
- Continuous On Screen Operation Status
- Selectable All Metals Tones
- Expanded Iron Range
- Phase Error Readout
- Analog Controls
- Elliptical Search Coil
- Superior Pinpointing and Wide Sweep
- Ergonomic Pistol Grip
- Arm Strap Included



FISHER GOLD BUG

*Finds the smallest gold nuggets
in highly mineralized soils*

- Discrimination Mode for Coinshooting and Relic Hunting.
More than a Hot Gold Machine!
- Auto-Tune Mode
- No-Motion Pinpoint
- Two Ground Balancing Options
 - Computerized Ground Grab
 - Manual
- Continuous Ground Condition Readouts
 - Ground Phase
 - Ground Mineralization
- Controls and Features
 - Threshold
 - Dual Headphone Jack
 - Gain
 - 5" DD Searchcoil - Standard
 - Signal Strength Indicator
 - 19kHz Operating Frequency
 - Target I.D.
 - 11" DD Elliptical Searchcoil Available as Optional Accessory
 - Depth Indicator
 - Ultra Lightweight
 - 2-Tone V.C.O.
 - Fisher Ingenuity!
 - Ultra Simple User Interface

7. A "paystreak" is a zone (typically narrow) in a placer deposit where gold is concentrated.
8. A "mother lode" is a lode large and rich enough to have resulted in the formation of mineable placer deposits.
9. The "Mother Lode" (capitalized) is a regional alignment of geologically related lodes, tens or hundreds of kilometers in length, which has resulted in formation of placer deposits of large extent many of which cannot be identified as having any specific lode as their source.
10. Gold which is gradually being carried downslope from a vein source by erosion and soil creep is often called "eluvial gold". I prefer to use the phrase "hillslope gold", since the geological processes are called "hillslope processes" in scientific geology.
11. The phrase "eluvial gold" most properly refers to gold which is being concentrated in place by geological processes such as wind and water erosion which remove lighter material.
12. A "pediment" is a relatively broad and flat upland which is very slowly being lowered by erosion. In most regions a pediment is characterized by soils of limited depth overlying bedrock. However in desert regions pediments are often alluvial fans and bajadas the source streams of which no longer exist. "Bedrock" may be thousands of feet (a kilometer or more) below the accumulated flash flood sands and gravels.
13. "Artisanal mining" is labor-intensive small-scale mining which requires low capital investment and does not rely on sophisticated knowledge of geology. It extracts only a small percentage of the total gold resource at that site. Searching for gold with a metal detector is a form of artisanal mining that didn't exist (as a practical matter) until the advent of VLF metal detectors forty years ago.
14. "Industrial mining" is large-scale mining requiring large capital investment and the use of heavy machinery. Industrial

mining operations are based on sophisticated geological research and are efficient at extracting most of the gold from the site. Such operations are usually large underground mining complexes or large open-pit mines.

Placer deposits are usually best worked by hydraulic methods if water is available. Modern “drywashers” and portable recycled water systems are much better nowadays than they used to be, and are effective for working dry placer. Placer gold tends to be smaller than hillslope gold because the process of being tumbled along a stream bed breaks larger nuggets into smaller ones, meanwhile wearing down nuggets of all sizes.

Alluvial (water flow) processes tend to concentrate what gold is present at specific spots, so if you hit a “hot spot” (paystreak) you may do very well. If you’re searching for gold in stream placer, learn to “read the stream” to figure out where heavy sediments such as gold will tend to accumulate.

Placer gold is almost always associated with magnetite black sand. VLF metal detectors tolerate black sand in moderate concentration, but in heavy black sand they lose sensitivity, become noisy, and “overload”. Under conditions of very heavy black sand the user must lift the searchcoil up away from the black sand in order to continue searching. Of course the ability to detect small nuggets is lost.

“Desert placer” comprises coarse sediments, often very deep, eroded from a parent mountain and deposited by flash floods and debris flows. In most cases drainage patterns are constantly changing as flow channels become clogged with debris and floodwaters find another course. On a given spot it’s often hard to say where on the mountain the material came from. “Reading” the chaotic distribution of material in desert placer is an art difficult to learn, but those few who learn it are privileged to dig where nobody else has dug.

In some cases the parent mountain no longer exists. When a desert placer land surface is no longer situated where deposition

Note for USA readers: the Avoirdupois ounce in everyday use equals 28.35 grams.

The price of gold

The “standard” price of gold is the “spot” wholesale price at which gold is bought and sold through international public electronic gold markets, which operate something like public stock exchanges.

The most popular spot gold reporting website is Kitco:

www.kitco.com/charts/livegold.html. The charts show current spot price almost minute-by-minute, as well as history from 1 day out to 10 years.

Natural “raw” unrefined gold is typically between 75 to 93% pure. Natural gold too small to be used as individual pieces in jewelry is usually purchased by refiners indexed to the spot value of its actual gold content. It’ll be indexed at somewhat less than 100% of spot because of the cost of operating the refining business.

Natural gold large enough to be used “as is” in jewelry or in mineral displays is usually indexed to 100% of spot, with more beautiful or interesting pieces fetching a considerable premium over spot. Gold-in-quartz (or in other matrix) specimens often cannot be indexed precisely to spot because of difficulty in accurately measuring the amount of gold in the specimen, in which case the “beauty/interest” factor plays a more important role in determining the price.

**Lots of great gold machines made right
here in El Paso! Gold Bug 2. Gold Bug.
F5. Omega. T². F75. F70.**

Formation is excellent. Very active forum for metal detecting gold prospectors. For historical reasons, most of the people who post there are PI machine users but much of the information is applicable to VLF use as well. Not one of our dealers, but you never know, that could change.

www.goldfeverprospecting.com Internet storefront, huge selection of gold prospecting merchandise, Fisher dealer. Located in California.

<http://forum.treasurenet.com/index.php/board,6.0.html>

Treasurenet's "Metal Detecting for Gold" forum. Fairly active. This forum is not biased toward any manufacturer or specific region, so you get a broader perspective than on most other forums.

Note: there are many good Internet sites and I can list only a few here. If you know of a site you'd like to see listed in the next edition, please contact our sales department (not myself) with the information, and ask them to pass the information along to Dave J. The primary purpose of listing sites here is to equip people with knowledge; selling metal detectors is secondary. Criteria for inclusion are: 1. The site's primary focus must be on gold prospecting, including metal detectors. 2. It has to be outstanding or unique in some way. 3. The site doesn't have to feature our brands of metal detectors, but it helps. 4. Non-USA sites will be given preference over USA sites. 5. I have to like the site.

The Troy weight system

The standard unit of measure of precious metals on international exchanges is the Troy Ounce. (This should not be confused with the "ounce" of the Avoirdupois system used in ordinary commerce in the USA.) The international unit of weight for almost everything besides precious metals commerce is the kilogram.

1 Troy pound = 12 ounces = 373 grams

1 Troy ounce = 20 pennyweights = 31.1 grams

1 Troy pennyweight = 24 grains = 1.555 grams

1 Troy grain = .0648 grams

processes are active, weathering disintegrates the surface material and it is washed away by surface erosion. The gold, being heavy, is not so readily removed by erosion. It's something like a very slow natural sluice. Over many thousands of years the gold becomes concentrated in the surface material, producing an eluvial deposit.

Metal detectors have revolutionized artisanal gold mining of hillslope gold. Apart from "booming" and "hydraulicking" which are banned everywhere because of their environmental destructiveness, there is no practical way to mine hillslope goldother than by using a metal detector. The old timers who had no metal detectors walked right over the top of big gold nuggets but they had no way of knowing the gold was there.

Weathered-in-place residual gold (typically in soil above a gold-bearing quartz vein) is a good situation for metal detecting, fairly similar to a hillslope setting. The difference is that if you see quartz stones and think there might be a gold-bearing quartz vein beneath, prospectors before you probably saw and thought the same thing. So, there will probably be prospect holes and possibly even nearby hardrock mines. The early miners were looking for a mineable hardrock vein, but without a metal detector the overlying soil was useless to them. So always check the zone around prospect holes, as well as the prospect hole itself if it's safe to do so.

Mine tailings (mullock heaps) from hardrock mines are another favorite place to search. The old timers threw the rocks out if they didn't see gold with their eyes, and they often got so busy throwing out rocks that they missed seeing visible gold. A metal detector can find their mistakes.

In many placer deposits, metal detectors go together well with the non-electronic traditional artisanal mining methods of panning, sluicing, and dredging. The larger rocks in the placer gravels can't be processed by these methods, so they have to be thrown out. Someone already dug these rocks from a suspected or known paystreak: now they're on the surface loose, and

probably even clean. Unless you happen to know that the larger rocks in this placer deposit virtually never contain gold, the rock piles can be a good place to use a metal detector.

Metal detectors are occasionally used in hardrock (lode) mines to check mine walls to see if there is a gold vein hidden in the rock which ought to be excavated.

In humid regions the soil is usually 20 inches (1/2 meter) or more thick, protected from surface erosion by vegetation cover. Gold is heavier than soil and tends to settle to bedrock. Therefore the gold is too deep to be detected with a metal detector. With the geology hidden underground, it's hard even to know where one ought to be searching. Therefore in humid regions the use of metal detectors is usually restricted to searching material which is not covered by soil—river gravels, rock outcrops, and rocky material excavated in mining operations. The use of metal detectors has historically been most profitable in arid regions. Desert soils are usually thin and rocky, with gold often lying exposed on the ground due to removal of lighter material from the land surface by erosion. And unlike in most humid regions, you can see the geology to guide you to where you should be searching.

Learn the geology of the area where you're prospecting. Learn what geological processes created the gold, and what geological processes put the gold where it is now. Learn to identify the various rock and mineral types which are typical of that area. When you look at the landscape, try to imagine what it looked like a million years ago, or even a billion years ago if the geology is Precambrian. Then imagine what processes took place to create the landscape you see in front of you now. Being able to visualize the flow of gold through the landscape will help you make intelligent guesses as to which zones will produce gold and which will not.

About Gold

Most gold machines will find gold nuggets weighing less than 1 grain (.064 grams). There are several models which can detect tiny 1/10 grain pieces under good conditions—so small as to be

www.detecting.com First Texas Products' *Bounty Hunter*, *Discovery*, and *Pioneer* series metal detector website: also most Teknetics models.

www.tekneticsT2.com Began as the website for the Teknetics T² model, but is transitioning into the website for the entire Teknetics product line.

www.nightowloptics.com and www.igen2020.com Our Night Owl and iGen division night vision products. The iGen is new technology we developed and nobody else has anything like it. When you're camped out, being able to see in the dark is very convenient. It could also possibly save your neck from animal or human predators.

Factory sponsored Fisher and Teknetics forums are hosted on the following sites:

www.americanrelichunters.com

www.thetreasuredepot.com

www.findmall.com

Internet sites relating to metal detecting including gold prospecting

www.akmining.com Everything related to recreational and small-scale mining in Alaska. "Bricks-and-mortar" store + online store. Lots of information on website. The owner is very knowledgeable in metal detecting and is a Fisher dealer.

www.arizonaoutback.com Lots of information on this Arizona dealer website. The essay Understanding gold deposits in the "gold prospecting resource center" is excellent. Very knowledgeable people. Fairly active forum. Fisher dealer.

www.nuggetshooter.com Dealer site, located in Arizona. Good information on the site: The Geology of Coarse Gold

ZIP ZIP Mastering Your Nugget Detector Revised 2nd Edition. Larry Saltee 1996 World Publishing. Excellent book, much detail. Emphasis is on how to use the metal detector. Larry is the primary “tester” I worked with in the field developing the “tracking” system of the White’s GMT.The sequel is **Zip Zip The Advanced Course** 1997. More really good stuff. NOTE: A much expanded edition has been published, **The Complete, Unabridged Zip Zip** but I don’t have a copy.

Books by Jim Straight: **Follow the Drywashers, Vol.3** (reprinted as **The Nuggetshooter’s Bible**). **Nuggetshooting Dryplacer Areas. Advanced Prospecting & Detecting for Hardrock Gold**. Some of the information on specific models of metal detectors is a bit out of date but the principles of searching for gold remain the same. Jim Straight is highly regarded in the metal detecting gold prospecting community. Many gold prospecting supplies stores carry his books.

www.icmj.com ICMJ’s Prospecting and Mining Journal, available in print or electronically. Began as a California and Nevada mining journal many years ago but journal content is now becoming more international. Good links on the website to information of interest to USA gold prospectors, but little of relevance to prospecting outside the USA.

First Texas Products and Fisher Research Labs Websites

Check our websites for current information on what products are available and where to obtain them. Our websites also include user’s manuals, essays on metal detectors and how to use them, and links to other friendly websites and forums.

www.fisherlab.com Fisher Research Labs website. You’ll see that we also manufacture industrial underground locating equipment and security metal detectors. At the moment this website contains more information of interest to gold prospectors than do our other websites.

almost invisible. The overwhelming majority of gold in the ground is small stuff. Large nuggets are very rare: they are found more by luck than by skill. You have to be finding the small stuff (especially the 1 to 10 grain size range) for gold prospecting with a metal detector to pay off.

A metal detector will detect the tiniest gold only within about 2 inches (5 cm) of the searchcoil. A pennyweight (24 grains, 1.56 grams) nugget can usually be detected 4-8 inches (10-20 cm) deep depending on the machine, ground conditions and user skill. High iron mineralization content will greatly reduce depth.

A one Troy ounce (31 grams) nugget can usually be detected at more than 8 inches (20 cm) depth, but again this depends on many variables.

“Flour gold”, such as is recovered by panning, cannot be detected by a metal detector unless there is a fairly substantial mass of it. The reason is that the electrical resistance of loose powdered metal is much higher than that of solid metal.

The distribution of gold size varies by location, by previous prospecting history, and by your own detecting capability. In the Western U.S. the distribution tends to be medium size although it varies greatly by location. In the Eastern U.S. the gold tends to be small, although large nuggets are not unheard of. Alaska has a reputation for larger gold than the Western U.S. Australia is famous for producing large gold, but most areas there have already been worked over with metal detectors. The size distribution is now smaller overall than it used to be because so much of the large gold has already been found. In gold producing areas around the world where there is little or no prior history of use of metal detectors, the size distribution of gold tends toward large.

On a particular site, gold will not be scattered uniformly. It will tend to be clustered in “pockets” or “hot spots”. You may be searching in a productive area and yet go the entire day without finding any gold at all, and the next day you may hit a “hot spot” and dig gold totaling half an ounce or more. When you

find a “hot spot” make sure you get it all: gold is where you find it. ...Some prospectors haul the dirt from a hot spot to a place where it can be panned or sluiced out. This way you get a lot of gold that can’t be found with the metal detector by itself.

Electromagnetically active minerals in the soil and rocks

Nearly all soil and rocks contain a variety of minerals, the magnetic or electrically conductive properties of which interfere with the operation of metal detectors. The “big three” are magnetite, maghemite and sodium ions. But first, some definitions.

Susceptibility refers to a material’s ability to attract a magnetic field. In the context of metal detecting, it corresponds to the amount of magnetically active mineralization in the soil. It is often expressed as an equivalent percent by volume concentration of magnetite.

Tangent of loss is the ratio of magnetic energy absorbed by a material and dissipated as heat, divided by the magnetic energy which is attracted to the material and not dissipated. The tangent of loss is most commonly expressed in arctangent form as the loss angle. In the context of metal detecting, it corresponds to the ground balance point of the soil. In a general way it represents the type of mineralization present rather than the amount.

Magnetite (ferrosic oxide) is a heavy black iron oxide mineral which exhibits high magnetic susceptibility and low magnetic loss angle. It is commonly found as “black sand” or as dense black rocks. It is strongly attracted to a magnet. It usually “balances” near the ferrite calibration point of the metal detector, which on most detectors is within the range of 80 to 95% of full scale. Many black colored rocks, especially igneous (volcanic & extrusive) and high-grade metamorphic rocks, contain appreciable amounts of magnetite. So do many rocks with a bluish or greenish cast, especially rocks in ultramafic greenstone belts. Magnetite in the soil is usually in the form of sand, because

Government agencies

www.usgs.gov United States Geological Survey. Such a vast resource, it’s almost impossible to say how vast it is. In 1995 the US Bureau of Mines was broken up and most of its functions relating to mineral resources were taken over by the USGS.

www.blm.gov United States Bureau of Land Management. A lot of land in the Western US is owned by the BLM and a lot of the recreational prospecting that’s done in the Western US is done on BLM land. This is where to find out what lands are owned by the BLM and what the regulations concerning their use are.

* * * * *

Next are two examples of State agencies concerned with gold mining. To find other similar State agencies, do an Internet search on the words “mines” and the name of the State in question.

www.conservation.ca.gov/CGS/Pages/Index.aspx State of California Geological Survey. Began as “Mining Bureau” but evolved into a California version of the USGS.

www.admmr.state.az.us State of Arizona Department of Mines and Mineral Resources. Includes good information on recreational mining in Arizona.

Print publications (including electronic media)

Advanced Nugget Hunting with the Fisher Gold Bug Metal Detector Heydelaar & Johnson 1988 Fisher Research Labs. Out of print, but available in .pdf format on our Fisher website. Although it was written around the “old” Gold Bug, the intended audience was anyone who uses a metal detector for gold prospecting. Nearly everything in the book is still useful. The information on the mineralogy of metal detecting is much more detailed than what you find here. The only error I’m aware of is that I said siderite is gray when in fact it’s brown.

Organizations

www.goldprospectors.org Gold Prospectors Association of America (GPAA). Largest organization of its kind in the USA, excellent website. They publish a print magazine. They own many gold claims which members can search on, and publish a directory of those claims. If you prospect for gold in the USA, you should be a member and should join a local chapter. There are other good “gold clubs”, often local, but they don’t replace the GPAA. If you don’t live in the USA, you’ll still find the website informative.

www.fmdac.org Federation of Metal Detector and Archeological Clubs, Inc. Very different from GPAA. Emphasis is on metal detectors, not on gold prospecting (although that is one use of metal detectors). Their activity is directed primarily toward education and legal issues, and working primarily with other clubs and with manufacturers. In the past their concept of “membership” was that of other organizations, clubs, and manufacturers, but they are now promoting individual memberships. FMDAC is primarily a USA organization, but there is one chapter in Canada.

www.igu-net.org International Geophysical Union. Its orientation is academic, and toward professional research in geology and geophysics.

www.agu.org American Geophysical Union. Like the IGU, its orientation is academic, and toward professional research in geology and geophysics. However its emphasis seems to be more on public communication and less on collaboration with government and international quasi-governmental agencies. Despite the name, nowadays it’s thoroughly international. I’m a lifetime member.

particles smaller than sand unprotected by rock matrix tend to oxidize to maghemite or to be dissolved by organic acids.

Maghemite (gamma ferric oxide) is an earthy iron oxide mineral found in most soils and some rocks. Red iron rust is a form of maghemite with which everyone is familiar. Maghemite is formed by the oxidation of lower oxidation state iron minerals such as magnetite, free iron and pyroxene. The oxidation commonly happens through weathering and exposure to fire. Maghemite is usually reddish brown or red in color, and even in low concentrations its color tends to dominate the material it’s in. Like magnetite, maghemite has high susceptibility. It differs from magnetite in having a substantial loss angle, causing it to ground balance in the range of 40 to 80% of full scale on most metal detectors and under most conditions.

Maghemite is often confused with the similar-appearing earthy hematite. However hematite has low magnetic susceptibility and therefore doesn’t usually affect metal detectors very much.

Sodium ions are produced when soil moisture dissolves salt or alkali, causing the soil to become electrically conductive. This effect is strong on ocean beaches but weak under most soil conditions. Usually just described by metal detector users as “salt”, soil electrical conductivity “balances” near 0% of full scale on most metal detectors.

Most iron-bearing minerals exhibit magnetic effects similar to that of magnetite (i.e., low loss angle), but with much lower magnetic susceptibility. Hematite, limonite and siderite are common examples. The black forms of limonite and hematite are often mistaken for magnetite by the untrained eye.

Soils high in maghemite tend to form most readily in warm humid climates, and by weathering of basalt. Fire tends to increase the maghemite content of rocks and soils by oxidizing magnetite and other ferrous minerals to maghemite which is a ferric compound. Subtropical and tropical laterite soils (oxisols) and laterite rock usually contain moderate to high concentrations of maghemite.

The “ground balance point” of a soil represents the weighted average of the ground balance points of the various minerals in the ground. As the relative concentration of these minerals changes from one spot to the next, the ground balance point will usually change also.

“Hot Rocks”

Nearly all soils found in gold prospecting areas contain “hot rocks”. A hot rock is a rock which does not contain gold, but which causes the metal detector to sound off. They come in two basic types.

Negative hot rocks (also called “cold rocks”) are usually magnetite or contain magnetite. They give a negative response because their ground balance value is a higher number than the soil they are found in. They tend to be dark in color, and are often heavy because of their iron content. In some cases they will have rust stains. They are usually attracted to a magnet, and for this reason gold prospectors always carry a magnet—the ultimate ferrous/nonferrous discriminator. In motion all metals mode, negative hot rocks produce a boing sound rather than the zip sound of a metallic target such as gold. Another difference is that as you sweep back and forth over a sound to check it, a zip sound will seem to stay in the same place whereas a boing sound will seem to be in two different places and to wander around. Learn these differences and you will be able to ignore negative hot rocks.

Positive hot rocks are usually iron-bearing rocks which have been oxidized by natural weathering processes, such that their ground balance number is a number lower than the soil they are found in. They are often small, right on the surface, and sound just like a gold nugget. They are common in many gold prospecting areas. They are usually, but not always, drawn to a magnet. They are most often reddish in color but are often black, brown or even yellow.

A special category of positive hot rock is electrically conductive rocks. In gold prospecting situations the most common

Appendix

Learning more

You’ll be searching for gold in some specific region, very likely where there is a history of gold mining. There are probably mining supplies stores with knowledgeable owners and customers. Such stores almost always carry maps, books on the geology of the area, and books on how to use mining equipment including metal detectors.

In the USA, there are gold prospecting clubs, many of them affiliates of the GPAA. You can learn a lot by joining a gold prospecting club and meeting with other people who do gold prospecting.

Nearly all countries have government agencies which publish maps and other information on geology and mining activity. In the USA, the largest such agency is the US Geological Survey. Most US States also have agencies which publish information on geological information and mining activity within their borders. In addition, Universities often have a department of geology which publishes information.

Manufacturers of metal detectors usually publish information on how to use the products they manufacture. Sometimes they publish information of broader public interest: the original Fisher Gold Bug prospecting manual (sorry, out of print!) was an example, and the document you have in your hands now is another example, in some ways the successor to the original Fisher Gold Bug prospecting manual.

Nowadays a lot of information that used to be available only in print is now available on the Internet.

There are Internet forums dedicated to gold prospecting with metal detectors, as well as to specific models of metal detectors. These can be good places to ask questions and to learn from people who have been successful.

To hunt solo, or with a partner?

In the USA, many metal detecting gold prospectors enjoy gold prospecting as a hobby and as a chance to be outdoors by themselves, enjoying the solitude. Others prefer to go gold prospecting with a friend or group of friends, in order to share costs and have fun together. Since gold prospecting areas are often remote and sometimes dangerous, it's advantageous to have someone else to help get you out of trouble.

When two people are prospecting together and both are using metal detectors, the detectors will interfere (crosstalk) with each other if they are too close. In some cases you will not hear the interference but there will be a loss of sensitivity. The separation distance required may be as little as 3 meters (10 feet) or as much as 30 meters (100 feet), depending on which models of detectors are being used. In general, two VLF machines operating at substantially different frequencies can work fairly close together without electrical interference. Some VLF machines have built-in frequency shifting capability which will allow two machines of the same model to be used closer together than would otherwise have been necessary. Pulse induction machines equipped with large "mono" searchcoils usually require a large separation distance from other metal detectors in order to avoid electrical interference.

In many other countries, gold prospecting with a metal detector is usually a means of earning a living. Two people working together can often be much more productive than one, where one person uses the metal detector while the other is a helper who carries supplies and does most of the digging.

electrically conductive hot rocks are sulfide ore (peacock ore, pyrrhotite, etc.) crystals. These can sound just like a gold nugget, but in many geological settings the gold is not found in the same type of rock as the sulfide ores. Therefore the sulfide ore signals can be ignored once the host rock can be identified. A few geological settings include graphite or graphitic slate rock which tends to give a very broad signal which does not sound like gold and which cannot be ground balanced out. If the rock sounds like metal, is black in color, and you can write on paper with the rock as you would with a pencil, you've got graphitic rock. In order to use a metal detector where there's graphitic rock you'll probably have to reduce the sensitivity setting of the metal detector.

Meteorites

If you're searching in a desert area, learn to recognize meteorites. All are valuable, and some are worth more than their weight in gold. There are many different kinds of meteorites, but most commonly they will look like a lump of magnetite. However unlike magnetite, meteorite response on a VLF metal detector will almost always be positive.A good rule of thumb is that if you encounter a positive hot rock that is black or dark gray in color except perhaps for rust stains, and it doesn't look like other positive hot rocks you find on that site, save it. Remember where you found it, and attempt to identify it later.

The subject of how to identify the various types of meteorites is too complex to go into here. (This book is about gold, not about meteorites.) Nowadays there's lots of information on the Internet, and recently several books have been published on the subject. Often it takes a meteorite expert to be able to say whether a particular rock is terrestrial or is a meteorite. In the USA, most of that expertise is found in Arizona where there is a lot of metal detecting in the desert, several meteorite strewn fields, and a long regional history of interest in astronomy and astrophysics within the University system. (Note: a "strewn field" is a zone of meteorite debris caused by the explosion of a large meteor high in the atmosphere.)

The iron and nickel metal in meteorites is usually what makes them detectable with a metal detector. Searching for meteorites with a VLF gold machine is pretty much like gold prospecting, except that hot rocks become a whole lot more interesting. The disadvantage of standard PI (pulse induction) gold machines for meteorite hunting is that when they're ground balanced, their response to the iron and nickel metal and iron minerals typically found in meteorites is greatly subdued.

Using a magnet as a “hot rock discriminator”—a summary

- Iron metal is *always* strongly attracted to a magnet. Steel (iron alloys) are almost always strongly attracted to a magnet.
- Magnetite hot rocks and black sand are *always* strongly attracted to a magnet.
- Other negative hot rocks are *almost always* attracted to a magnet, but not as strongly as magnetite.
- Positive hot rocks are *usually* attracted to a magnet, but the attraction is often weak.
- Meteorites detected by a metal detector are *usually* attracted to a magnet. The attraction may be strong or weak.
- Gold and other nonferrous metals are *never* attracted to a magnet.

Always carry a strong magnet with you when prospecting. Many prospectors use a pick that has a magnet either built in or attached. For further information see the section Extracting a target from the ground.

Ground mineral anomalies

Conductive mineral salts usually produce broad signals which will not be mistaken for a metallic object. Common causes are concentrations of mineral fertilizer, spots where evaporation has concentrated natural mineral salts, residue from de-icing salts and urine from livestock. Unless completely dry, “cow pies” can sound off like they are metal.

geologist's pick with hammer face is the preferred tool. Estwing is the industry standard.

4. If you're detecting in a streambed environment, you may want specialized “crevicing tools” for extracting gold nuggets from cracks in bedrock.
5. You'll probably want a belt-mounted hammer holster to carry your pick-hoe digger and/or rock hammer. Dealers who sell the tools often sell the holsters. You can probably find a suitable holster at a building supplies store that sells carpentry tools.
6. Small hand-held “pinpointer” metal detectors can be useful for locating gold in a loose pile of dirt, or just below the surface of a rock. Most such pinpointers are designed primarily for detecting coins, and lack the sensitivity needed to detect small gold. The “Falcon” is expensive by pinpointer standards, but has the sensitivity needed for gold prospecting. There may be others equally as good, but I'm not aware of them.
7. Instead of a small hand-held “pinpointer” metal detector, some prospectors prefer a “pinpointer coil probe” which works like a searchcoil on your metal detector. A pinpointer coil probe attaches to your metal detector through a switch box. When you want to use it, you pull it free from its clip and then flip the switch. The performance is usually excellent because the probe is powered by a high-performance metal detector circuit. And, the control panel (user interface) is the one the user is already familiar with. They are typically manufactured by third parties as an aftermarket accessory. Personally, I don't like pinpointer coil probes because they're so cumbersome, and because they usually throw the ground balance setting off. Sometimes the switch box electrical components even throw off the ground balance setting of the standard searchcoil.
8. Plastic cup or scoop. You put a handful of dug material in the cup or scoop, and pass it over the searchcoil to see if the metal detector “sounds off”. Then you know the object you've dug is in the cup or scoop, and not still on or in the ground.

Miscellaneous subjects

Digging tools

The preferred digging tool for gold prospecting with a metal detector is a hand “pick-hoe”, pointed on one end and broad on the other end, with a wood handle, weighing less than 1 1/2 kilos (3.3 lbs). A magnet for “collecting” iron metal and hot rocks may be integrated into the tool by the manufacturer: if not, you can figure out how to attach a magnet of your choice. Depending on construction and features, the price of this kind of digging tool will usually be within the range of US 15 to 90 dollars. Examples which can be found through Internet search include “Groundhog detector pick”, “Hoe Pick”, “Hodan Pro Pick”, “Jobe Treasure Pick/Mattock”, and “Apex Badger 18 inch”. The Groundhog is popular, and is what I use.

Other digging tools worth mentioning include the following:

1. Estwing Geo/Paleo Pick. I did a whole lot of gardening in Prescott Precambrian granite with one of these. A wonderfully balanced tool of the highest quality, light and precise, for one or two hand use. All steel. Too large and too much metal to be convenient if you're VLF gold prospecting by yourself, but great if you go prospecting with a partner. The Geo/Paleo Pick breaks up and moves rocky dirt deeper and faster than a smaller hand pick. It is also much more effective than a small hand pick in breaking loose fractured or weathered rock. The “hoe” end does a good job cutting roots.
2. Lesche Digging Tool. This is shaped like a garden trowel with a serrated edge for cutting roots. Most gold prospecting areas are too rocky for it to be of much use. If you also do coin and relic hunting in areas that aren't rocky, this may be your preferred digging tool. Widely available through metal detector dealers and also through us (Fisher Research Labs) direct.
3. If you're detecting on a site where gold is often in rocks which must be broken open in order to see what is in them, a

In some areas “clay domes” are a feature in the soil which will typically give a broad audible response. It often happens that if you dig the clay, the signal disappears. This is usually because of the loss of electrical continuity within the clay, but may be the result of loss of alignment of microscopic magnetic particles within the clay.

In spots where there has been intense fire, such as a campfire site or where a stump was burned during land clearing, the soil minerals may be altered by oxidation so that their ground balance setting is lower than that of the surrounding soil. In such cases, search slowly and change the ground balance setting as frequently as necessary.

In some areas, electrically conductive industrial minerals such as fuel coke, slag, clinkers (left over from burning mineral fuels) or charcoal have been dumped or used as landfill. Such lumps will usually have a broad signal, not crisp like a gold nugget usually is. If you're searching an area where there is a lot of contamination by such materials, do not dig unless a signal is crisp and repeatable.

There are rare ground conditions where the layering of magnetic and electrically conductive properties within the soil causes ground balance to try to “go backwards” when lowering the searchcoil to the ground. Under these conditions manual balancing and “grab” usually won't work. You will probably never encounter this condition, but if you do, set the ground balance to a value which seems best to you and it will probably be usable while sweeping horizontally at reduced gain. The most advanced tracking systems may acquire good balance while sweeping horizontally under this condition even if they lock out while “pumping” vertically.

Single-frequency VLF “gold machines”

How VLF metal detectors work

The searchcoil assembly (also called search head or “loop”) contains two electrical induction coils which are like antennas. One coil is a transmitting antenna which is surrounded by a rapidly alternating magnetic field. If metal is present, the alternating magnetic field will induce current to flow in the metal.

The other coil in the searchcoil assembly is a receiving antenna which detects changes in the magnetic field caused by the electric current circulating in the piece of metal. Electronic circuits amplify this weak signal, analyze it to determine the changes which occur as the searchcoil sweeps over the target and then convey the information to the user in the form of a visual display or audio tones. Most modern metal detectors perform some of these tasks in software running on an internal microcomputer.

The iron minerals which are present in most soils distort the magnetic field, obscuring the weak signals of small or deep metal objects. This can cause the object to go undetected, or to be misidentified when it is detected. Much of the technology that goes into modern metal detectors is devoted to the task of eliminating the unwanted signals from iron minerals in the soil, while not losing the signals from metal objects.

VLF “gold machine” metal detectors in general

Single-frequency VLF “gold machines” typically cost from US\$500 to \$1200 list price (or somewhat less discounted). They always have a high performance “motion all metals” mode which can be “ground balanced” to the specific ground where you are searching. The “all metals” mode is usually of the type called “autotune” or “first derivative”. The operating frequency of units currently available (January 2010) ranges from 6 to 71 kHz. The higher frequencies tend to be more sensitive to the smaller nuggets (so small you can hardly see them), and the lower frequencies tend to be more sensitive to larger nuggets.

Ground balancing cannot be tested or demonstrated in air unless you happen to have appropriate specimens of iron minerals available.

Electrical interference

It used to be that electrical interference wasn’t much of a problem with gold prospecting machines. But over the years the machines became more sensitive, and more electronic equipment (including other metal detectors esp. PI’s) started showing up in the goldfields. Electrical interference is now an important issue even for gold prospectors.

Electrical interference can be caused by power lines, appliances, computer equipment, cell phones, fluorescent and vapor type lamps, household light dimmers, other nearby metal detectors, electric fences, radio transmitters, and electrical storms. If you get abnormal noise while holding the searchcoil motionless in the air, the cause is electrical interference or internal circuit noise. By walking around with the metal detector, you can often *follow the signal* and track it back to the offending device; simply turn the device off, or come back at another time when it may be off. If the interference is from power lines, you might try another time of day. Interference on power lines is usually caused by something connected to them which may be idle in the evenings or on weekends. If the interference is from a communications or broadcast transmitting antenna, reducing the sensitivity is usually your only recourse. Cellphones transmit even when you’re not talking on them, so turn your cellphone off when you’re searching unless you know your metal detector isn’t affected by it.

Some metal detectors provide “frequency shifting” which allows the operating frequency to be shifted slightly in an attempt to move away from the frequency that the electrical interference is at. This maneuver is effective only with certain types of electrical interference. It is ineffective when the electrical interference is broadband (for instance from thunderstorms or an electric fence), or when it enters the electronics directly from high frequency communications signals without coming through the searchcoil.

their weight, and by the white surface color they acquire in many soils. In many areas the most troublesome nonferrous metal is birdshot from hunters. The birdshot does have one good attribute, though—if you're digging birdshot, that's telling you that you've got the machine set up right to find gold.

When you extract a target that turns out not to be gold, don't just dump it back onto the ground. Put it in a trash pouch so it won't be there to bother the next person who searches for gold in the area.

Always double-check the signal!

When you remove a target object, never assume that it's the only thing there. Check that hole again. Check that pile of dirt again. Make sure you remove all the targets and that you're leaving none behind.

Air testing (demonstrating) a metal detector

There may be times when you want to test or demonstrate the metal detector without sweeping it over the ground, for instance if not fully assembled, or if you are indoors. To air test, place the searchcoil in a spot where the detector is stable and more than two feet away from any large masses of metal, including the reinforcing steel usually present in concrete.

If you are wearing a wristwatch or jewelry on your hand or arm, remove it. Then, test or demonstrate by waving metal objects over the searchcoil. Wave them briskly, several inches over the top of, and parallel to, the searchcoil.

Gold machines are sensitive enough to "see" your hand up to several inches away, because your body is electrically conductive. The palm of your hand is a big enough target to mislead you into thinking you're detecting a small piece of gold in your hand when all you've got is dirt. Learn to keep the palm of your hand several inches away from the searchcoil when testing small targets or when digging targets in the field.

However, sensitivity depends on many variables besides frequency. Machines within the frequency range of 13 to 50 kHz are the most popular. Machines from 13 to 20 kHz usually include a discrimination mode suitable for general purpose use. A few machines have the ability to change operating frequency to adapt to different sites, but this may not confer an advantage over a machine which is optimized at one particular frequency.

First Texas Products – Fisher Research Labs "gold machines" Made in El Paso, Texas, USA

As of Jan 2010, we manufacture the following single-frequency VLF metal detectors suitable for gold prospecting. They're listed in order of operating frequency.

Gold Bug II: 71 kHz, gold prospecting only, high performance. Manual ground balance only.

"new" Gold Bug: 19 kHz, gold prospecting and general purpose, high performance. Manual and "grab" ground balance.

F75 & T²: 13 kHz, general purpose and gold prospecting, high performance. Manual and "grab" ground balance.

F70: 13 kHz, general purpose and gold prospecting, high performance. "Grab" ground balance only.

F5 and Omega: 7.8 kHz, medium to high performance in general purpose use, and medium performance in gold prospecting use. Manual and "grab" ground balance. The Omega lacks independent control over gain and threshold.

History of user acceptance: The Gold Bug II is widely regarded as being able to find nuggets smaller than any other machine on the market. It is still a popular unit after 14 years of production.The T² has recently gained popularity for gold prospecting in Africa. A few USA users have tried gold prospecting with the F75 and report generally good results.The T², F70, F5, and Omega have so far received very little use as gold machines in

the USA so no general statement can be made about what users report for those models. Although we expect the new Gold Bug to be well received, it is too new to be able to say what customers think of it.

Chief Designer's Opinion: When the new Gold Bug has been fully released to the market, it will be the best choice for many gold prospecting customers. The T² may “look wrong” for gold prospecting but it is a very good performer especially when equipped with the small 5 inch DD searchcoil, and a little easier to learn than the somewhat similar F75. For the person on a budget who wants a general-purpose machine which can do casual gold prospecting, I recommend the Omega (preferably with 5 inch searchcoil) because it is so easy to use; however fans of the somewhat similar F5 would argue the advantages of the F5's separate threshold control. The Gold Bug II is best suited for the experienced diehard gold prospector “detectorist”: someone new to gold prospecting with a metal detector may find it a difficult machine to master.

We always have new products under development. By the time you're reading this, we may have other models suitable for gold prospecting, so please check with your dealer or our marketing department for up-to-date information on what's available. Note however that they will probably not provide any information on products which may be under development and are not yet available for sale.

First Texas Products – Fisher Research Lab's design engineering capability is the best in the world. I've been engineering commercial metal detectors for 28 years and previously designed and built vehicle detectors and roadway loops for the State of California. My first gold machine was the original Fisher Gold Bug which revolutionized VLF gold prospecting and remained in production for 16 years. Over the years I've worked for other companies designing metal detectors including gold machines. If you've wondered why this very essay is so “nonpartisan”, it's because so many of our competitors' products are Dave Johnson designs. Our consumer metal detector engineering team also

2. Dig. Remove ground material over to the side in a pile and spread it out a bit. With the metal detector, check the hole and the pile to see if the position of the target has moved. Keep this up until you move dirt and the metal detector says that the target has moved with it.
3. You will probably not be able to see the target, and will have to narrow its location down further. Some people use a plastic cup, put a handful of dirt in the cup and sweep the cup across the searchcoil until they hear the “zip” sound. Other people like to dump a handful of dirt onto the searchcoil and listen for the “zip” when the target hits the searchcoil.Some people know exactly what their empty hand sounds like going across the searchcoil. They hold a fistful of dirt in their hand: if there's gold, they hear the difference.All these methods work, but the plastic cup method works best for most people.
4. Keep dividing the dirt down until you finally locate the target. Remember that a little nugget that's been in the ground for a few million years will often look just like part of the dirt. You may know almost exactly where it is and may be looking right at it, yet not be able to see it. Knowing where it is, and being able to pick it up, are not the same thing. You'll get better with practice.
5. When you've finally found it, put it in a suitable container.

Dealing with trash metal and hot rocks

You'll probably dig a hundred pieces of trash metal and hot rocks for every piece of gold you find. The single most useful gadget for dealing with trash metal is a good magnet, sold by all gold mining supplies stores. Most of the trash metal on a gold prospecting site will be either iron and steel (chips off shovels and other mining equipment, rusted barbed wire, flakes of old tin cans, boot nails, etc.) or brass and lead from firearms. A good magnet will pull iron and steel metal and most hot rocks out of a handful of dirt. Brass is usually easy to spot by its color especially if it has corroded to green. Intact bullets are usually easy to spot by

Checking a target

When you hear that “zip” sound, even if it’s not very distinct, you’ve got something that might be a “digger”. Before you dig, you want to determine (if possible) whether it is worth digging. You also want to know precisely where to dig.

1. Sweep back and forth over the target at several angles. If you sometimes get a “boing” sound it’s probably a hot rock. If it’s consistently a “zip” sound it deserves further investigation.
2. Look. In most areas, positive hot rocks have a typical appearance and don’t contain gold. If you see a rock that looks suspect, kick it aside with your toe and see if the sound goes away. If it does, it was a hot rock. Not a “digger”.
3. If the target object is still there, you still don’t know if it’s gold or something else. You *may* want to switch to the discrimination mode if your machine has one, in order to gain more information about the target. If you decide it’s iron or a hot rock, you can leave it there.WARNING: Discriminators “lie” on weak signals and in highly mineralized ground. When gold prospecting, never trust the discriminator unless you are experienced enough to know what it can and can’t do. If you are a beginner, it is fine to check the target with the discriminator, but whatever the discriminator says, dig the target anyway. This is how you’ll get enough experience to learn when the discriminator can be trusted.

Extracting a target from the ground

1. If the target object is still there and you didn’t decide it was iron or a hot rock, you’re going to have to dig it up. In most gold prospecting terrain this will require using a hand pick designed for this specific purpose. First locate the target as best you can. Do a north-south sweep over the target and then an east-west sweep in order to see where the sounds intersect. (This maneuver is called “X’ing the target”.) Don’t bother with static (non-motion) pinpoint mode if the machine has it: that’s for people looking for coins in the park, not for gold prospecting.

includes John Gardiner (Bounty Hunter expert and project engineer on the F75 and several other products) and Jorge Anton Saad (project engineer on the Omega and several other products).

Each manufacturer has their own emphasis and approach to metal detector design. Our emphasis is on getting the basics of metal detection right, good ergonomics and keeping things simple for the user. We aren’t much into gimmicks or having an extravagant feature list.

Choosing the gold machine that’s right for you

There is no one “best” gold machine, just like there no one “best” car. There’s only the one that’s best for you (or maybe several of them if you’re really serious). Here are some things to take into account when choosing.

1. Any metal detector will detect gold nuggets if they’re big enough, but most gold is small stuff. If you’re planning to do gold prospecting, you should get a machine which is capable of doing at least a halfway decent job of it. There are good medium performance “coinshooting” machines down to about the US\$200 level. However, highly capable gold detection requires specialized design, and you won’t get medium performance gold detection for much under \$500.
2. If you plan to do general metal detecting (coins, jewelry, relic hunting, etc.), you can get that capability without spending more. However the low operating frequencies required for general purpose metal detecting mean you will sacrifice a little bit of sensitivity to the smallest gold, compared to what could have been achieved at a higher frequency.
3. There is not necessarily a close relationship between price and performance. Features and branding have a lot to do with price.
4. For most people, buying from a local dealer is better than buying over the Internet because the dealer will usually be able to provide good advice on what to get for your purposes. Pricing at local dealers is usually about the same as from

Internet dealers or only slightly higher. Some Internet dealers provide very good service although they can't literally demo a machine for you.

5. Manual ground balancing capability is important for many users: however some people just can't get the knack of it and require a machine that offers computer-assisted ground balancing, either "grab" or "tracking". Tracking may sound like a good feature, but it's like driving an automatic transmission car on a narrow winding mountain road—constantly changing and unpredictable. With "grab" there is no tracking and you can get a repeatable signal when checking out a target. We changed the market perception of tracking when we introduced the Teknetics T²—customers asked "where's the tracking?", we said "you don't need it", they replied "by golly you're right!" and that was the end of it. We may offer tracking in the future, but for now none of our products has it.
6. About operating frequency: there are gold machines the operating frequency of which ranges from about 6 kHz up to 71 kHz. The highest frequencies are best for the tiniest gold, which of course is most common. Finding small gold keeps you in the "gold is where you find it" groove so you're more likely to swing the searchcoil over larger gold. The lower frequencies tend to be easier to ground balance especially in moist ground conditions, and to give slightly better response to large nuggets. The frequency range of 13 kHz to 19 kHz is especially popular because it's a good compromise for gold, and because this frequency range is also suitable for general-purpose metal detection (which the higher frequencies aren't).
7. Multiple simultaneous frequency machines presently on the market are not suitable for gold prospecting, with the exception of the very expensive White's V3 which is really intended for other uses.
8. The prevailing gold machine technology at US\$1500 list price and up is pulse induction ("PI") with ground balancing capability. The operating principle is different from VLF and

height above the ground but close to the surface, occasionally touching the surface. Don't lift the searchcoil at the end of your sweep—keep the movement flat.

In general, if the searchcoil is more than 16 inches (40 cm) in front of your toes, you will not be able to maintain a good sweep pattern without a lot of effort: about 1 foot (30 cm) is usually about right. HOWEVER, if your shoes or boots have steel shanks or steel toe protection, or are carrying a lot of metal objects on your belt, you may find it necessary to extend the searchcoil farther out in front to avoid detecting that metal.

"Gold is where you find it." If you're searching in an area you know to be productive, go slowly and methodically. Overlap your sweeps in order to get something like 100% coverage. If you do not do this, you will walk right over gold and not hear it, because you didn't sweep the searchcoil over it.

In general, a faster sweep will find larger, deeper gold targets but will tend to miss small shallow gold. A slower sweep will tend to lose sensitivity to the deepest targets, but will "see" small shallow gold better.

Each model of gold machine has its own preferences regarding sweep speed. Some machines are sluggish, and if you sweep fast the ground will get noisy and the response to shallow targets will be smeared. Some other machines have good response with a faster sweep and may easily lose deeper targets if you slow down too much. Learn what sweep speed works best for the machine you're using.

In any case, sweep at a comfortable speed. Going too fast leads to poor control over the height of the searchcoil above the ground, leading to inability to hear small shallow targets through ground noise. It can also cause stress failure of mechanical components of the machine. Going at a moderate to slow pace enables you to pay close attention to what you're doing with a minimum of fatigue.

The following step-by-step “beginner instructions” are for the Teknetics T², but can be adapted to most gold machines under most conditions.

1. Set the sensitivity to 60. (This is a moderately high gain setting.)
2. Set the hum level (audio threshold) to +1. (This is a clearly audible background hum.)
3. Cancel ground minerals using the FastGrab procedure. (It can also be done manually if you know how.)
4. Sweep the searchcoil over the ground, and listen.

If you’re hearing a lot of ground noise, reduce the sensitivity setting until the sound of the ground is barely audible while sweeping.

If you don’t hear ground noise while sweeping, increase the sensitivity setting until you do hear ground noise. If irregular background chatter from electrical noise increases too much, raise the hum level (audio threshold) setting to “bury” the chatter.

Some ground may be so lightly mineralized that you don’t hear it even at high sensitivity settings. In this case, set sensitivity very low, adjust the hum level to your preference and then increase the sensitivity setting until you hear irregular background chatter from electrical noise.

Other control settings

Some machines provide user control over response speed (fast or slow) or other behaviors of the machine. Consult the owner’s manual for details on how to use these additional features.

“Sweeping” (moving the searchcoil over the ground)

Move the searchcoil back and forth over the ground surface at a slow but deliberate speed. Maintain the searchcoil at an even

the ground balancing issues are also different. The main advantage of a good PI is its ability to work in heavily mineralized ground without much loss in depth, especially on the larger nuggets. The disadvantages are cost, weight, poor response characteristics, tendency to miss the smallest nuggets, poor sensitivity to meteorites, high power consumption, and rudimentary feature list. Because what a PI will and won’t find is quite a bit different from what a VLF will find and won’t find, some users will cover an area with both a PI machine and a VLF machine in order to “clean it out” a lot better.

.....Some PI users have convinced themselves (having spent so much money) that no VLF machine can match the performance of a PI. That’s certainly true in some conditions. But there are also prospectors who have both a good PI and a good VLF and prefer the VLF on most sites.We do not presently offer a PI, but our Chief Designer has done PI’s in the past and may do so again in the future. We can’t do everything at once, and for now our emphasis is on VLF.

9. Most gold machines are available with at least two different sizes of searchcoils. Advantages of small searchcoils: higher sensitivity to the smallest nuggets, ability to get between rocks and bushes where larger searchcoils won’t fit, lighter weight, reduced interference from ground minerals, easier to pinpoint the exact location of an object and less electrical interference. Advantages of larger searchcoils: broader sweep (covers more area), slightly more depth (but not as much as you’d think). A popular compromise is an elliptical searchcoil about 10 inches (25 cm) in length by about 6 inches (15 cm) wide, providing some of the advantages of both large and small searchcoils.On a really productive site, some people will search it thoroughly first with a small searchcoil to find the gold “hot spots” and to remove trash metal and hot rocks, then work the area again with a larger searchcoil to better detect any larger deeper targets which may be present. If the detector has “speed control” (which won’t necessarily be called that -- consult the user’s manual), use a slower electronic/software speed setting when the larger searchcoil is installed. It’ll get more depth.

10. Some gold machines can be purchased with searchcoils in either the concentric and double-D (DD) configuration. The big advantage of DD's is that they penetrate ground minerals deeper than a concentric. Minor advantages of a DD compared to a concentric of similar overall size and shape are a broader sweep (wider coverage) with tighter target separation. However, DD's have numerous disadvantages: greater vulnerability to electrical interference, confusing multiple signal responses on shallow objects, inferior shallow iron discrimination when used in discrimination mode, greater manufacturing cost and often less sensitivity to the tiniest nuggets. For gold prospecting the advantages of the DD usually outweigh the disadvantages. However the situation is not so clear-cut with small searchcoils where concentrics are often more sensitive to the tiniest nuggets.

Using a VLF metal detector: techniques

Interpreting ground readout data

Some metal detectors provide a readout of the magnetic susceptibility of the soil, typically expressed in terms of an equivalent volume concentration of magnetite (even though the magnetism may result from other minerals besides magnetite). The depth to which objects can be accurately identified is strongly influenced by the magnetic susceptibility of the soil. High Fe_3O_4 (equivalent magnetite) values have a greater effect on detection depth in the Discrimination mode than in the All Metal mode. For the most accurate Fe_3O_4 reading, pump the searchcoil up and down as though you were ground balancing.

We often simplify matters by explaining that the magnetic susceptibility readout indicates the *amount* of mineralization. A representative example of a magnetic susceptibility readout is the one on our F75, as follows:

lose sensitivity to small nuggets. If you're serious about gold prospecting you have to find and dig those small nuggets.

Adjusting threshold and gain

Most gold machines provide an audio threshold control and also a gain control (sometimes called "sensitivity") for the motion all metals mode. The threshold control, when adjusted into its positive region, controls how loud the background hum is. This is mostly a matter of preference. Sometimes a user will adjust the threshold control into the negative region, which suppresses unwanted noise from electrical interference or ground minerals but it costs you the ability to hear small gold.Sometimes a user will adjust the threshold well into the positive region. This allows a higher gain setting to be used. This combination can be advantageous for a user who has some hearing loss, or in a situation where there's a lot of ambient noise.

The gain control adjusts the amplitude of the signals that control the audio circuit. It's not a "volume control" but it's a little bit like that. If you set gain too low, the sound change caused by small gold won't be great enough for you to hear it. If you set gain too high, the "background noise" sound will be annoyingly irregular or "ratty" even with the searchcoil held stationary in the air. In "noisy ground" (ground which is so inconsistent that ground balancing can't completely silence it) it is necessary to reduce gain so that the sound of the ground won't fatigue your ears. In general, the best setting is where the background sound irregularities, including from residual ground, are large enough that you can hear them, but not so large that the dips cause the background hum (controlled by the threshold setting) to go completely silent. ***Your objective is to hear the sound of gold through the slight background sound of the ground.***

Some users assume that more gain is always better. Actually, when there is electrical interference or noisy ground conditions, reducing the gain is how you get control over the response of the machine. That's the primary reason why the machine has a gain control.

you're probably someone who is going to prefer manual ground balancing even when the machine offers alternatives.

Manual ground balancing is done in the motion all metals (also called "autotune" or "first derivative") mode. Set the audio threshold so you can hear a constant but relatively quiet background hum, and set the gain high enough so that with the searchcoil held motionless in the air you can hear some "noise" (wobbling and fluttering) riding on top of the background hum.

Now lower the searchcoil to within about an inch (2.5 cm) of the ground and lift it again. If it sounds off on the way down ("pushing the sound into the ground"), the ground balance setting is too high. Rotate the ground balance knob to the left (counterclockwise) or press the minus button if it's a touchpad interface.If it's quiet going down but then sounds off on the way up ("pulling the sound out of the ground"), the ground balance setting is too low and you need to turn the knob clockwise or press the plus button. With experience you will learn to quickly converge on the "null", achieving either no variation or weak irregular sounds. Some people prefer to search at the null setting. However, most prefer to find the null and then to adjust the setting slightly higher, so that there is a weak but consistent positive response (i.e. the detector sounds off slightly when the searchcoil is approaching the ground).

If you can't "find the null" or the null zone is broad with loud inconsistent sounds, you may be trying to ground balance over a spot where there's metal or a hot rock. Try moving sideways a short distance and try again.

Searching in motion all metals mode

The motion all metals mode (sometimes called "autotune" or "first derivative" or by a proprietary trade name) is what you'll be using for gold prospecting. If your machine has a discrimination mode, you might use it for checking targets you've located in motion all metals mode but will almost never use it while searching for gold. The discrimination mode will

Fe₃O₄ BAR GRAPH (percent by volume magnetite equivalent)

Fe₃O₄	approx.	
Range	micro-cgs*	Description
3	7,500	uncommon but not rare, heavy mineralization
1	2,500	heavy mineralization, not uncommon in goldfields
0.3	750	heavy mineralization, but not uncommon in some regions
0.1	250	medium mineralization, typical of many areas
0.03	75	light mineralization, common in many regions
0.01	25	light mineralization, often low ground balance setting
blank	<14	quartz & coral white beach sands

Many "gold machines" provide a numeric scale on the dial of a ground balance knob, or a digital readout of the ground balance setting. A few provide a real-time indication of the ground balance point of the soil you're over, independently of where the ground balance has actually been set. The following information is for the F75 but most machines will be fairly similar.

The two-digit ground balance setting number displayed on the LCD indicates the *type* of ground mineralization. Some typical ground mineralization types are:

75–95	Magnetite and other black iron minerals
40–75	Red, yellow, and brown iron-bearing clay minerals
26–39	Very few soils in this range -- occasionally some saltwater beaches
10–25	Metallic iron. Very few soils in this range. You are probably over metal.
0–10	Wet salt and alkali

This pattern is typical only. Many soils do not fit this pattern because the machine is looking only at a particular magnetic property of the soil, and does not actually know anything about the color or texture of the soil.

**cgs = centimeter-gram-second (Gaussian) units*

Some metal detector models use the word “phase” in connection with ground balance. This is because the circuitry is analyzing the magnetic loss angle of the signal from the soil: mathematically this is expressed in degrees of phase. However, scaling ground balance in actual degrees would compress most of the action against one end of the scale. Therefore metal detector manufacturers usually rescale it nonlinearly in arbitrary percent-of-scale units so that most of the numeric range is usable.

Ground Balancing: an overview

All soils contain minerals which influence metal detector operation. The signals from ground minerals are often tens or hundreds of times as strong as the signal from a buried metal object. The “magnetism” (magnetic susceptibility) of iron minerals in the soil causes interfering signals which are primarily of the type called *reactive* by electrical engineers. Dissolved mineral salts, found in some soils, are electrically conductive, causing interfering signals which are primarily of the type called *resistive* by electrical engineers. On the ground balancing scale of most metal detectors, reactive signals are cancelled (balanced) in the high numbers and resistive signals are cancelled (balanced) in the low numbers. The mix of resistive and reactive interfering signals determines at what number the interfering signals will be cancelled (balanced).

“Ground Balancing” (also called “ground cancelling” or “ground phase adjustment”) is the process by which the metal detector sets the cancellation circuit or software to the proper “phase” to cancel the interfering ground signals. Depending on the model of metal detector, this may be achieved in one or more of the following ways:

1. Adjusting the value **manually** with a knob or up-down (plus/minus) buttons
2. By sampling the ground signals at a spot chosen by the user (“**grab**” feature), and letting the computer set the ground balance value based on analysis of those signals

ground tracking system, hearing a sophisticated one resist mistracking and dive almost instantly into new ground is uncanny.

I work for FTP-Fisher, so you might think it odd that I am describing the “tracking” systems of certain competitors’ models as being darn good (as such things go). Well, the boss hired me because I had a history of doing good work elsewhere! Far be it from us to be ashamed of that record. And, this booklet is written for everyone, not just FTP-Fisher customers.

Meanwhile, none of our products has any kind of tracking at all. Why not? Because, having designed what are widely acknowledged to be the best ground tracking systems in the business, I am well aware of their limitations. Since I came to First Texas Products in 2003 I have preferred “grab” systems, without tracking. When we introduced the revolutionary Teknetics T², many customers were surprised that there was no tracking system. We explained that the “grab” system filled the need better than a tracking system. Customers tried it out and agreed, and that was the end of people asking us to put “tracking” into our products. The market success of “grab” amazed even us. In the future we may introduce tracking, but it will likely be different from anything presently on the market.

Manual ground balancing

Most gold machines offer manual ground balancing. Some older (but still good) designs offer *only* manual ground balancing. Manual ground balancing has the advantage that the ground balance setting is set where *you* want it, not where the machine thinks it should be. The disadvantage is that you have to learn how to do it skillfully, and in some highly variable ground you’re going to be pretty busy trying to keep it balanced. Users whose machine offers either a “grab” function or a sophisticated ground tracking system most often prefer to let the machine’s computer do most of the work. If you’re one of those people who hates automatic transmissions and insists on a stick shift,

machine recovers ground balance fairly quickly and quiets down especially if you “pump” the searchcoil. Some machines allow you to turn tracking off to avoid “tracking out” targets you’re trying to detect. Although these systems are technologically primitive, they’re actually quite usable once you become accustomed to their response characteristics.

3. Late 90’s tracking systems developed by Dave Johnson: Tesoro Lobo Supertraq, White’s GMT & MXT, and spinoffs of those machines. The Tesoro and White’s systems are based on completely different underlying algorithms, but their behaviors are fairly similar. Although they are commonly referred to as “tracking systems” for historical reasons, the underlying algorithms are not based on the concept of tracking out errors. They acquire new ground balance quickly, yet exhibit stability unmatched by the more primitive servo-based systems.

The bane of tracking systems is that when you need a repeatable signal the most -- when you’re checking a target-- that’s when you can’t get a repeatable signal, because the tracking system tries to “track out” the target thinking that it’s part of the ground. The late 90’s “Johnson systems” *usually* will not be thrown off by a target *provided that you sweep wide past the target so that on every sweep the machine is seeing some ground that isn’t influenced by the metal target signal*. The problem is that when you hear a metal target, it’s instinctive to shorten your sweep to “check out the target”. Now the machine doesn’t know the difference between metal and dirt, and thinks it’s all dirt. And diligently “tracks it out”. If you forget the need for wide sweeps and start hearing the ground instead of the target, just move sideways a foot or two (about half a meter) where there’s no metal and pump the searchcoil up and down several times. You’ll hear the machine sounding off over the ground. When the detector decides it knows what’s underneath the searchcoil (usually in about 2 seconds) it will suddenly go quiet as it jumps to a new ground balance setting. If you’ve used a primitive

3. Letting computer software “**track**” variations in the ground signals and provide automated canceling without user intervention.

Calibration of the metal detector’s ground balance setting to the actual soil condition results in deeper detection of metal objects, quieter operation, and (in the case of discrimination or visual target ID) more accurate metal object (“target”) identification.

Positive and Negative Response

The purpose of ground balancing is to adjust the metal detector to ignore ground minerals. Users often describe this as “nulling out” the ground. If the setting is incorrect, ground minerals will give either a *positive* or a *negative* response, depending on which direction the adjustment is off.

POSITIVE RESPONSE

If the ground balance setting is too high a number, the response of ground minerals will be *positive*. This means that when the searchcoil is lowered to the ground in pinpoint, static (non-motion) search, or motion all metals autotune (first derivative) mode, the sound will get louder as the searchcoil approaches the ground. The sound will grow quieter as the searchcoil is raised. What, if anything, you hear in discrimination mode will depend on the discrimination mode settings, and differs from one detector model to another.

When searching in motion all metals mode, if ground balance is properly set to cancel the ground, when you sweep over a *positive hot rock*, the rock will give a “zip” sound similar to that of a metal object.

NEGATIVE RESPONSE

If the ground balance setting is too low a number, the response of ground minerals will be *negative*. When the searchcoil is lowered to the ground in pinpoint, static, or motion all metals mode, the machine will be silent. In motion all metals mode,

the machine will sound off as the searchcoil is lifted away from the ground. What, if anything, you hear in discrimination model differs from one detector model to another.

When searching in motion all metals mode, a *negative hot rock* will produce a “boing” sound after passing over it, making it difficult to know where it is actually located. It will not have the crisp sound and “feel” of a metal object.

Ground balancing using the “grab” feature

Some metal detectors offer a “ground grab” feature. How it is implemented differs from one detector model to another.

Usually, the machine collects ground data all the time that the searchcoil is in motion over the ground. When you activate the “grab” feature by pushing a button or flipping a momentary toggle switch, the ground data in the computer at that moment will be used to set the ground balance. However the data were probably collected while you were sweeping the searchcoil horizontally, reducing the amplitude and consistency of the data. Better quality data can be collected by “pumping” the searchcoil above the ground with about 6 inches (15 cm) of vertical movement several times before finishing the “grab” maneuver.

“Grabbing” will usually provide a ground balance setting which is as close to perfect as the machine can achieve in that spot. Many experienced users prefer a slightly positive response rather than a perfectly balanced “null” response. Of machines which offer a “grab” feature, most also offer manual ground balancing which can be used to raise the setting slightly to produce a positive response.

Ground balancing using “tracking” feature

Some metal detectors offer “tracking ground balance”. The *supposed* advantages of “tracking” are:

1. It makes life easier for the user by loading the task of ground balancing onto a computer, eliminating the need for user intervention.

2. Since the computer is always busy balancing the ground, the ground balance setting is never off. It’s always right.

Those good intentions are not actually achieved.

1. The user must now accommodate his/her sweep technique and “ear” to the peculiarities of the tracking system: user intervention is still required, it’s just of a different kind.
2. What the computer “believes” about the ground is based on past history, not on what’s under the searchcoil this very moment; and, it can be “thrown off” by metal or hot rocks.

I’m aware of three basic types of tracking systems on the market. And I have strong opinions about them.

1. Slow servo (null-seeking error-correcting) systems. Their behavior of “tracking out errors” is what gave the name “tracking” to fully automatic ground balancing systems. Since hot rocks and metal cause ground balancing errors, such targets throw the ground balance off. The design engineer, realizing this, makes the tracking action so slow that going over a target only throws it off by a small amount: therefore you can still hear the target. However, sweeping over a metal target several times to check it out throws off the ground balance by a lot. The fallacy of slow servo systems is that once you’ve thrown off the ground balance, it takes a very long time to recover. The best way to use a slow servo “tracker” is to pump it over a patch of ground where there’s no metal until you hear the ground response go fairly quiet, and then turn the tracking off.I’ve never inflicted a slow tracking system on a customer. If that’s what your detector has, it’s not a Dave Johnson design.
2. Fast servo systems. These were originally developed for gold prospecting about 20 years ago. Although they quickly mistrack over a hot rock or metal object, you can usually hear the target through the resulting ground noise. Once you’re beyond the detection range of the target object, the