DRAFT

Media Damage and Hard Drive Data Recovery

Many of our clients are stunned to learn that their hard drives have suffered significant internal damage. "But I only dropped it a few _____ "(inches or feet – fill in the blank) is the typical, surprised response. Sometimes they are too embarrassed to admit that anything out of the ordinary might have occurred. "It just failed", they say.

Whatever the cause, media damage, which is shown below as scratches on the platters (where the information is stored), presents a significant challenge to successful data recovery.

Figure 1 below shows the inside of a healthy drive. This model "parks" or leaves the head(s) on the platter surface, near the center hub, when it is turned off. Some other drives park the read-write heads in a ramp, off of the platter surfaces.

Note that the platter surface is clean and shiny, and the internal filter is white.

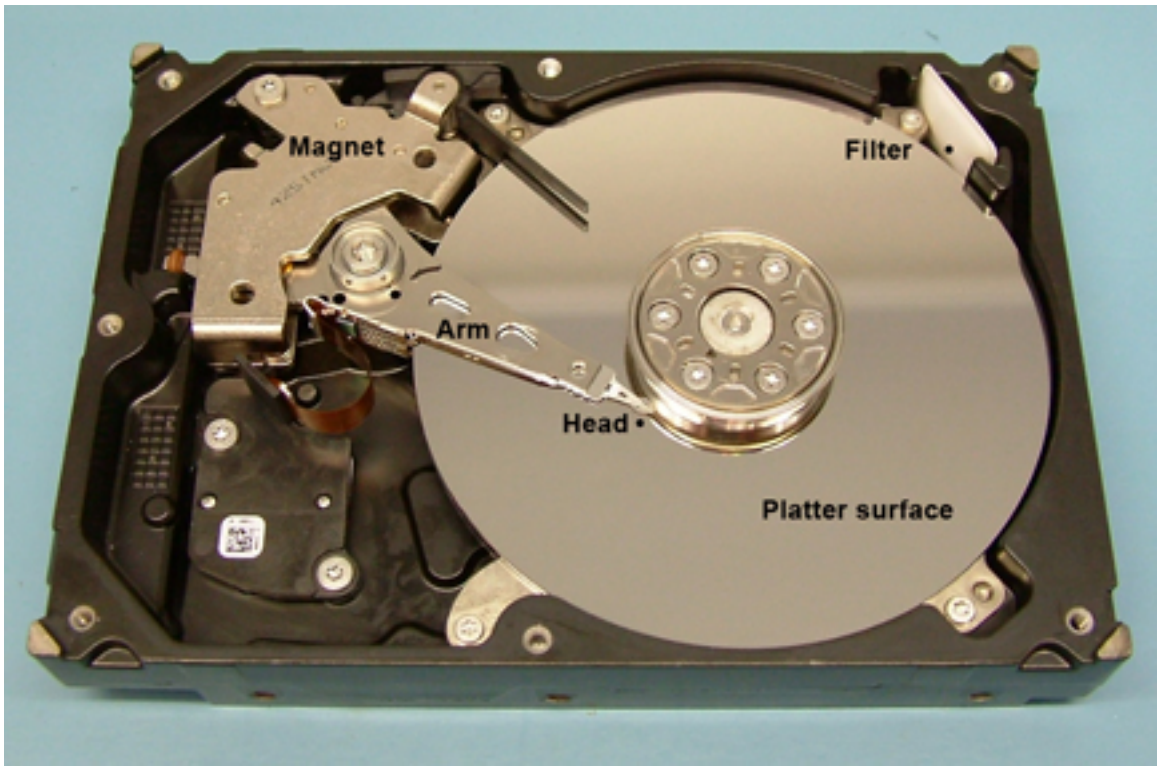

Figure 1. Inside of a Healthy Drive

During a mechanical drive's operation, the hard drive motor spins very fast, creating a very tiny cushion of air, which allows the head or to "fly" atop the platter surface. Many drives have multiple heads and multiple platter surfaces.

The head travels back and forth across the platter, rapidly locating, reading, and storing your data, without actually touching the surface (also called the *media*).

If the drive receives a physical jolt or shock, the read-write head may "crash" onto the platter media, and create a defect or "ding." A phonograph record serves as a good analogy: bump the record player while it is playing, and the needle will fly across the record surface, creating a permanent scratch. If the scratch is deep or severe, the record is ruined.

The next photo, **Figure 2**, shows what has happened to a drive that experienced a catastrophic head crash with media damage.

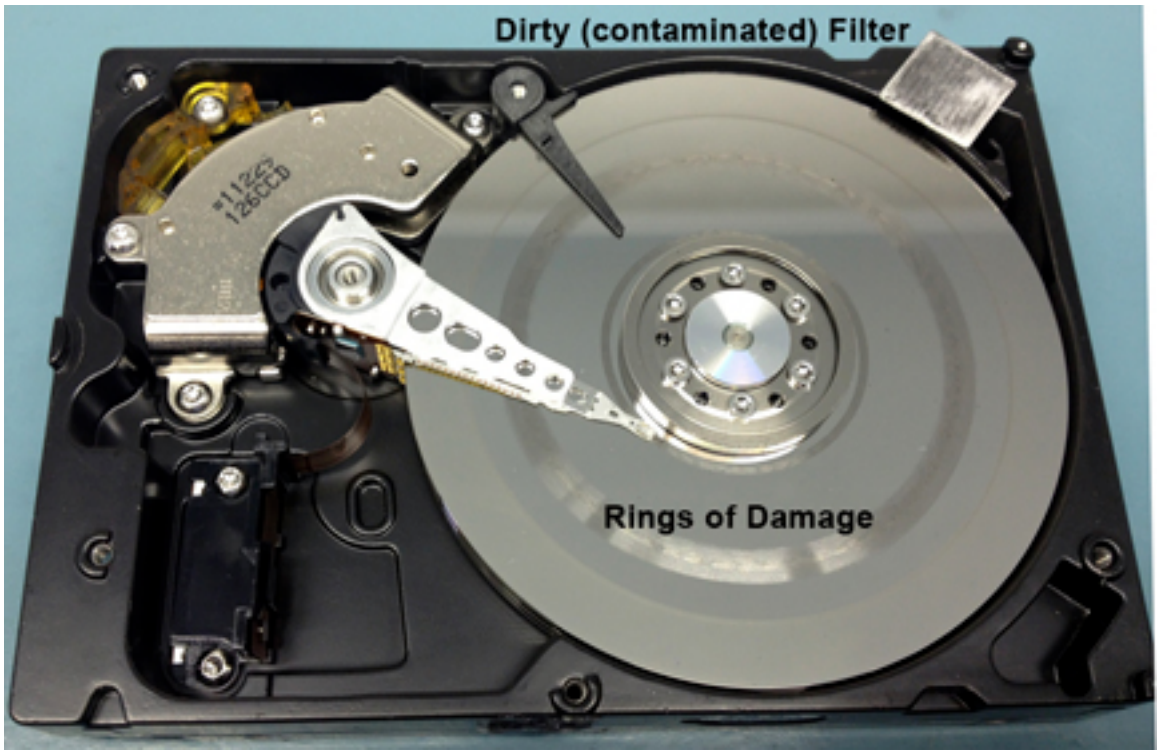

Figure 2. Drive with Head Crash & Media Damage

In this case, the "dings" become grooves in the surface, as the heads continue to scratch the platter as it rotates. Small particles generated by the scratch fly around the drive and eventually contaminate the *entire* drive, ruining other heads and creating more grooves. When this happens, we say, "your data is in the air filter." We call this "*cascading failure",* and at this point, data recovery is usually impossible.

At other times, a drive can receive a shock, and it (initially) causes only minor damage to the platter surface, such as a nick or light scratch. The drive may continue to function for a while. But in many other cases, operating the drive with media damage will eventually ruin the head and perhaps degrade to cascading failure, needlessly making a recoverable drive unrecoverable.

Therefore, if you operate a drive after it has been dropped or shocked, you are courting disaster. The safest thing to do after an accident is to immediately turn off the hard drive and bring it to a recovery facility, *if you value your data*. It still may be possible for the data recovery firm to transfer your data from the drive without much data loss or expense.

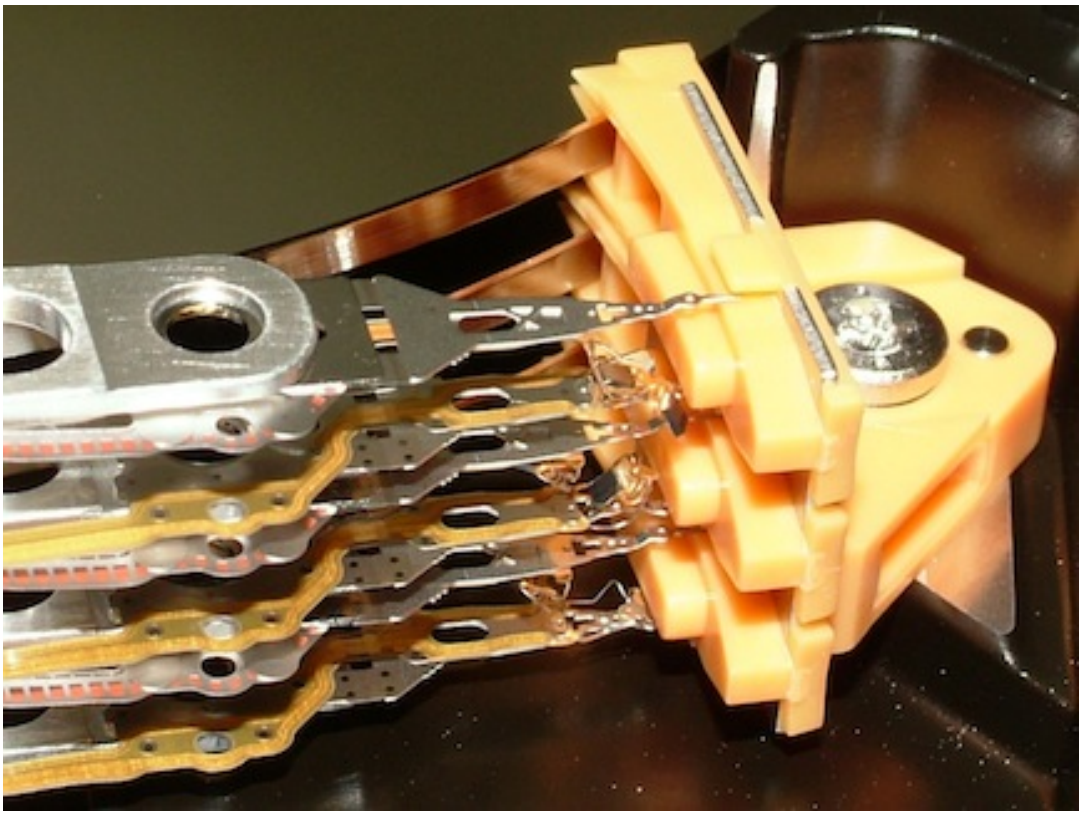

Figure 3. Damaged Heads Parked in a Ramp

It is generally true that a shock to an operating drive will cause more damage than to a stationary drive, a lot may depend upon whether the drive's heads are parked on the platter or on a ramp. But damage can occur to the heads even when parked on the ramp, if the force is severe enough.

Figure 3 shows damaged heads in a ramp. As soon as the drive is turned on, the deformed heads will move onto the platter and act like little knives, scraping data away and lessening the chance of recovery.

The debris kicked up by the process acts like large boulders randomly dropped onto a highway –– a crash is sure to follow. Particles larger than 0.25 microns cannot pass between the air cushion gap between the head and the platter.

Most media damaged drives fall somewhere between the two extremes. Often, there are minor scratches that will corrupt some of the data.

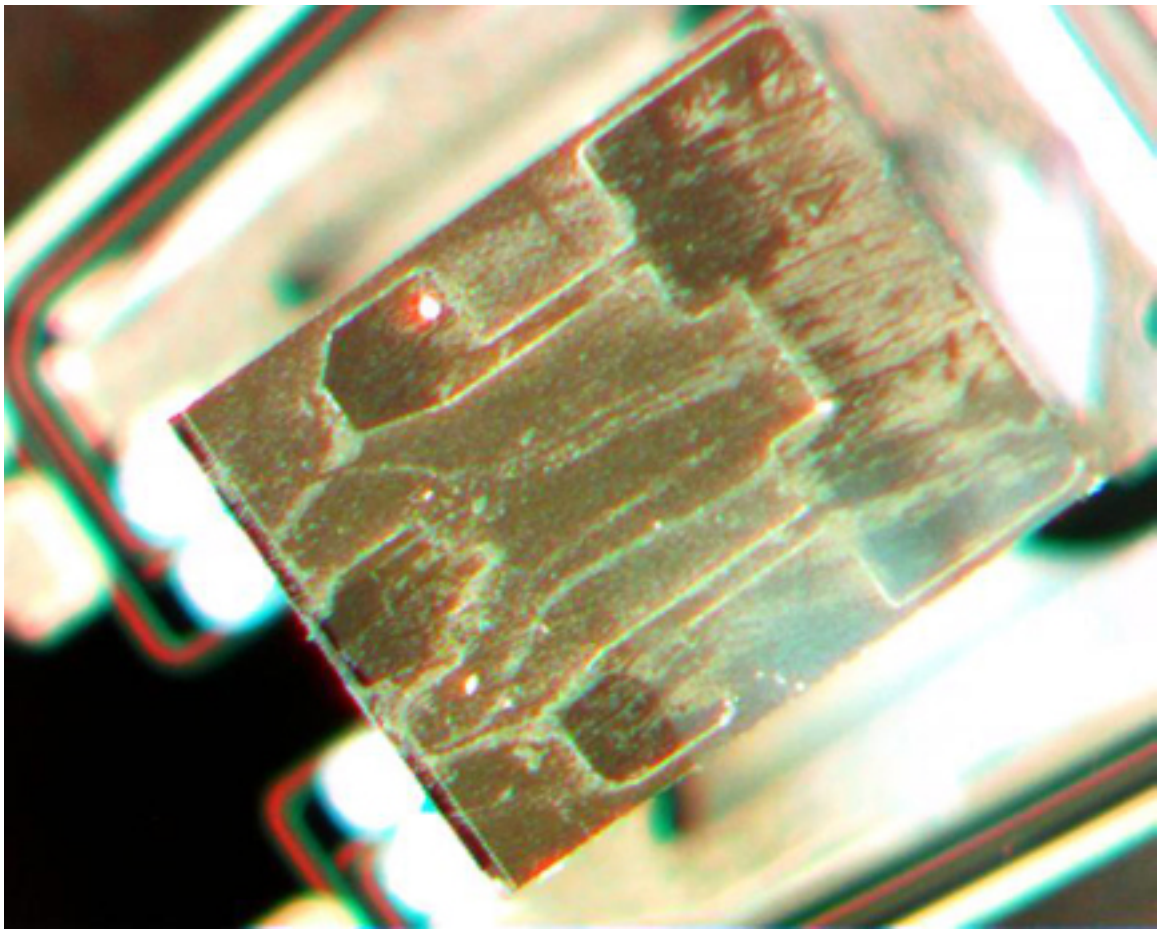

Figure 4. Close-up of Scratched and Contaminated Head

For perspective, the diameter of a human hair is about 80 microns, on average, which is 320 times larger. **Figure 4** shows a "crashed head." Scratches and debris (contamination) are clearly visible.

Crashed Drive Recovery Scenarios

Crashed drives fall into two broad categories: *recoverable* and *unrecoverable*.

Unrecoverable drives:

If we open a drive in our Class 100 work environment, and discover damage as extensive as shown in **Figure 2**, we would declare that case to be unrecoverable. The load of debris caught by the filter shows that the drive is completely contaminated, and an examination of the heads will probably look like **Figure 4**.

Data resides on the top surface of the platter. If the media has been scratched away, so has the data. Even a mildly dirty or contaminated head can create micro-scratches, which may not be apparent to the naked eye.

There is no practical, universal "platter reading machine." Damaged heads must be replaced with good ones from a suitable donor, before any data can be read. Also, the drive has to be completely decontaminated to prevent another head crash.

Even if donor heads enable the drive to start, once the heads contact a damaged area, they will be immediately ruined.

Every hard drive has a special *service area*, which contains the software for its operation, which manages defects, updating S.M.A.R.T. logs, etc. When a drive is first turned on, the heads travel to this area first. However, if critical files are damaged in the service area, recovery may not be possible. This is another reason why it is a bad idea to try to power cycle a damaged hard drive.

Recoverable drives:

Remember that data recovery is a salvage operation; this is particularly true for a dropped or jolted drive.

In the best scenario, media damage is minor, and a dropped drive can be copied (or *imaged*) successfully. Any damage will be in unused areas or in parts of the drive that do not contain important client data. A recovery of up to 100% is possible.

In a worse scenario, there is significant damage on one or more platter surfaces, and only a partial recovery is possible. Perhaps the very worst scenario is when only

partial recovery is possible, *and* the drive's directory, which contains the names and locations of the files, is corrupted or unrecoverable. In this case, we can retrieve – with some exceptions – only files by their types, without their file names or original folder locations. This is termed a *raw recovery*.

Most media damaged drives fall somewhere between the extremes. Often, there are minor scratches that will corrupt some files.

It is important to know a few basic principles of drive operation to fully grasp the problems, challenges, and limitations of partial recovery.

Most hard drives have more than one read-write head. During operation, the drive switches between heads, reading or writing to one head for a predetermined interval, and then switching to the next head. This is called *interleaving*.

Some hard drives –– like Maxtor –– read only a small bit of data before switching heads. On the other extreme, most Samsung drives will read more than a gigabyte of data before switching.

Let's suppose that your drive has four heads and one of them has failed, due to a scratch on the platter. In many cases, that head can be switched off or physically removed, and data is read from the remaining good heads.

Data located on an unread platter is <u>*not*</u> recoverable, unless it exists elsewhere on the drive, which is unusual.

Although a 75% recovery of data (three out of four platters) is the theoretical maximum, in practice it will be less. This is because any file that has any part located on the "missing" platter will be recovered as incomplete, i.e. corrupted. A drive switches platters automatically without regard to the integrity of the data files.

To use a crude analogy, recovering a drive without all of the platters is like cutting regular sections out of a book (see **Figure 5**). You will be able to read about a paragraph or so from every page, but then there will be a blank space before the text continues. The important thing to remember is that this "hole" in the data persists throughout the entire drive.

To continue with the analogy, a large percentage of small files (corresponding to individual sentences in our book) can be read intact. Larger files, such as videos or music, (corresponding to entire pages) can't.

In a raw recovery situation, the client will receive recovered files in folders according to type. Each file will have to be reopened, renamed if necessary, and saved to an appropriate place.

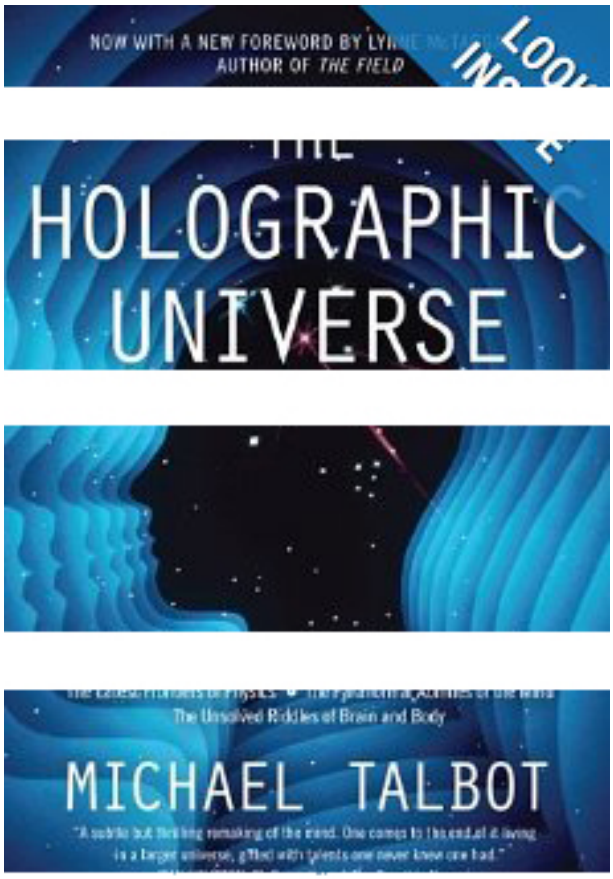

Figure 5. Interleave Analogy

Conclusion

Media damage presents a challenge to data recovery. In many, if not most cases, 100% recovery is not possible, and the client must decide if a partial recovery is going to be acceptable. It may not be practical to try to recover large files, such as music and video, if there is significant media damage.

Ironically, the amount of time, effort and expense required to perform a partial recovery is often a multiple of cases where 100% recovery is possible. As always, data recovery is a salvage operation.