APPENDIX A

JACK PARKER'S INTERIM REPORT DECEMBER, 2002

1. PURPOSE OF THIS REPORT: This is a response to a request by Michigan Dept of Transportation to evaluate the effects that an old gypsum mine beneath I-196 might have on the stability of that highway - in both near and long terms.

The request went to Michigan Technological University professor Stanley Vitton, Ph D. He enlisted me because I live near MTU, have worked in mines since 1946, here and abroad, and on mine stability problems in particular since 1955. One of my jobs, in the 1980's, was for Domtar in the mine in question.

2. BRIEF DESCRIPTION OF THE MINE. The mine operated for more than 100 years as Grand Rapids Gypsum, Domtar Industries, and finally as a Georgia-Pacific Gypsum, property, until 1999.

There are several sub-horizontal seams of gypsum. Most of the mining was done in #2 seam, until 1976. Additional mining was done in #4 and #5 after that - but not near the freeway I-196.

When the mine was closed in 1999 most of the files were lost or destroyed. At the beginning of this project, early in December 2002, Dr Vitton searched the remaining files at Grand Rapids and did find a few maps and reports of interest. He was also able to talk to two former employees - Mine Manager Charlie Johnson, Plant Manager Tom Mroczkowski, and is still attempting to contact engineer/geologist Wladyslaw Ochocinski.

Seam #2 varies in thickness but averages about 12 feet, of which a foot or so was left in the roof and a foot or two in the floor - so that mining height was somewhat less than 10 feet. The gypsum was left in roof and floor to minimize product contamination from shales, and to protect those shales from weathering.

A map of #2 level, believed to be complete and reasonably accurate, is attached to this report. We suspect that there may be minor survey discrepancies - tens of feet perhaps but not hundreds.

Large amounts of water began to enter the mine in 1964, and were pumped out continuously, but the pumps were shut down after mining ceased and the mine is now full of water. Entrances were inclined from surface but all of the mine workings are below the elevation of the nearby Grand River. It is unlikely that they will ever be seen again.

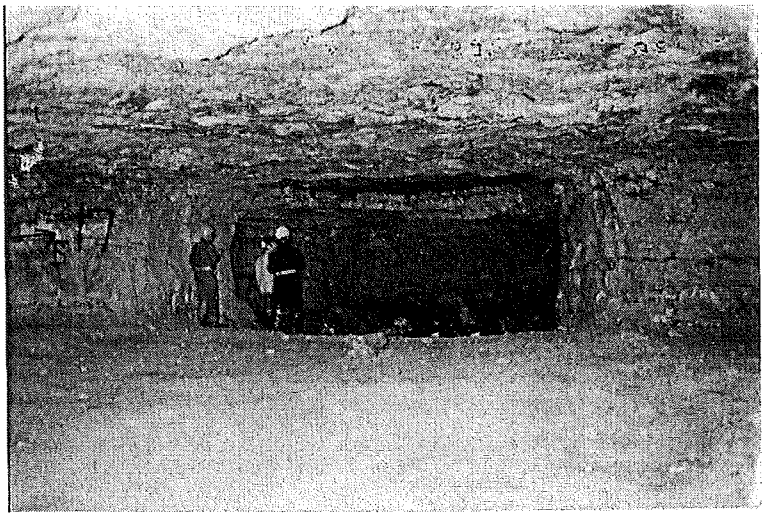
As you will see on the map, the mining layouts were changed often during the life of the mine, which often happens when new managements bring new ideas to a mine, but in general the mining technique is described as "room and pillar."

The rooms are rectangular tunnels, about 10 ft high and 20-30 ft wide, driven by drilling and blasting on a grid pattern, sometimes square, sometimes rectangular, sometimes parallelograms, sometimes random - to extract 60% or more of the area mined.

The "pillars" are the blocks of gypsum left in place between the rooms to support the roof and all of the rock and dirt above it. As the map shows, size and shape vary a lot, but the least width (which controls the strength) is generally around 20 ft, i.e., 2x height.

In some places the dimensions of the pillars were reduced by blasting to recover more of the ore, and in some places the remnants collapsed, allowing the overlying surface to subside.

In other places very large blocks were left unmined because the quality of the gypsum there was inadequate. Those places, of course, will never collapse. Obviously the weight of the overburden is not evenly distributed.



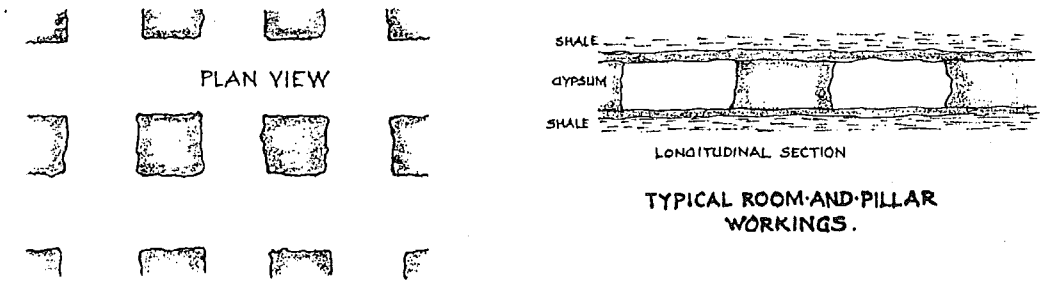


Figure 1. Photograph and illustration of room and pillar workings of the number 2 seam.

3. FREEWAY CONSTRUCTION. The freeway, as shown on the map at the end of the report, was completed in 1964, finished with 9" of concrete. In this stretch it has never been replaced and no structural damage has been reported with the exception of typical or normal distresses associated with concrete of this age.

We found an old map on which was a note saying that the workings on the east side of the mine, over which part of the freeway was built, were mined "probably before 1945." Signed "Mark."

4. RELATIONSHIPS BETWEEN UNDERGROUND FAILURES AND SURFACE STABILITY. We will discuss this in some detail because a clear understanding is essential if we are to reach useful conclusions and recommendations.

In normal underground mining, where the objective is to recover as much of the ore as possible, safely, but at minimum cost, a few roof failures are expected, and acceptable - provided that men

and equipment are not involved. A few chunks or slabs, even a foot or two, may fall from the roof, and they would be cleaned up or bypassed. If necessary artificial supports were added. Such falls would not be marked on the map - and they would not affect the surface.

In areas where pillar dimensions are reduced by "robbing" a complete collapse is expected, the remnants will crush and spread out and the surface will subside. The amount of surface subsidence will depend largely on the overlying geology:

If most of it is rock and the thickness is not great (say 40 ft or less) subsidence may be as much as 70% of mined height -7 or 8 feet.

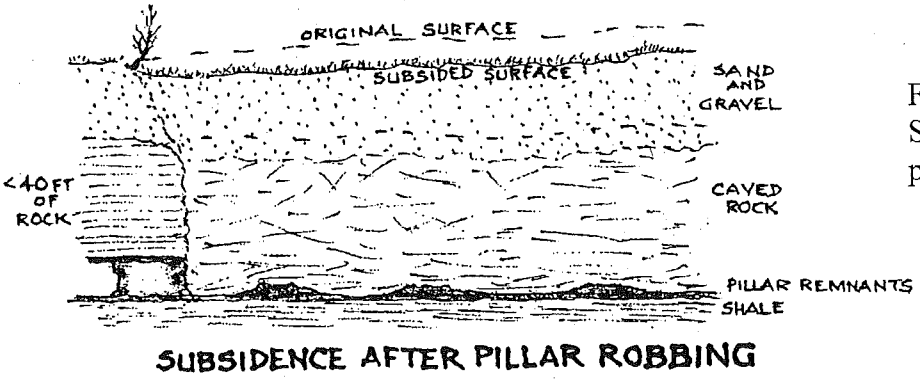


Figure 2. Subsidence after pillar removal.

If most of it is rock but it is thicker - the rock will "swell", i.e., fall in a jumbled state, taking up more space - then the amount of subsidence will be less, say 40%, or 4 ft.

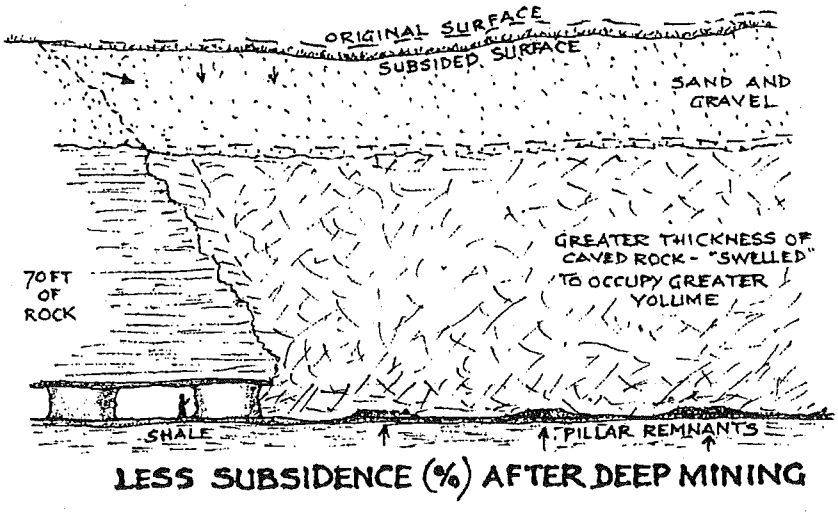


Figure 3. Less subsidence after pillar removal.

Adjacent to these falls some rock and much of the adjacent soil, sand and gravel will slump sideways into the subsidence basin, as shown in the above sketches. Thus there will be some subsidence beyond the limits of the underground collapse.

Thick sand and gravel will flow, or slump, especially when wet, so the basin may be broad and the limits may be indistinct.

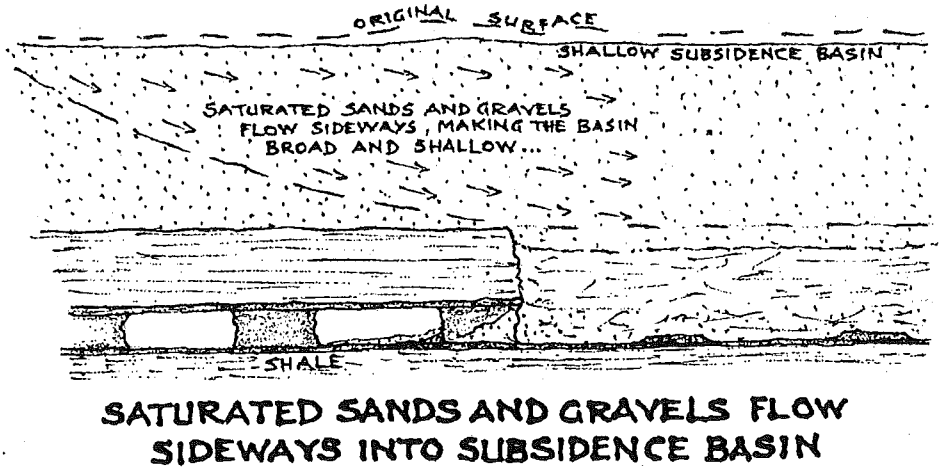


Figure 4. Subsidence with material flowing into openings.

Roof failures behave differently.

A small failure at shallow depth, say an intersection of two mine openings, may develop a natural arch or may go up to a stable roof horizon (such as the #1 gypsum above #2).

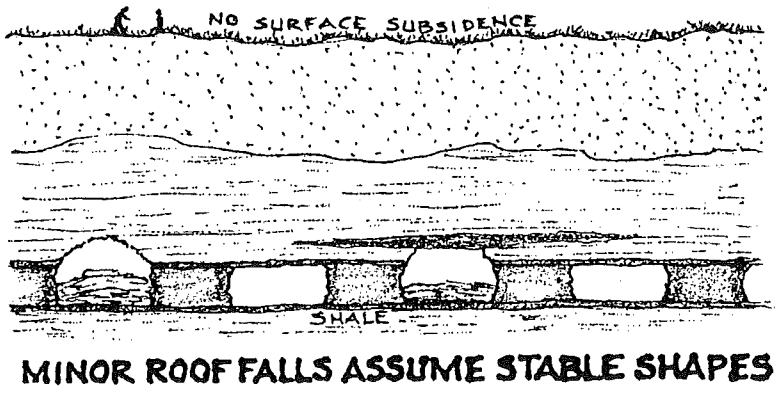


Figure 5. Minor roof falls assume stable conditions.

Several such failures may coalesce and go on up to top of bedrock, the base of sand and gravel. The fallen rock will partly fill the void but sand and gravel may fall in too, creating a well-defined ''sinkhole'' at surface.

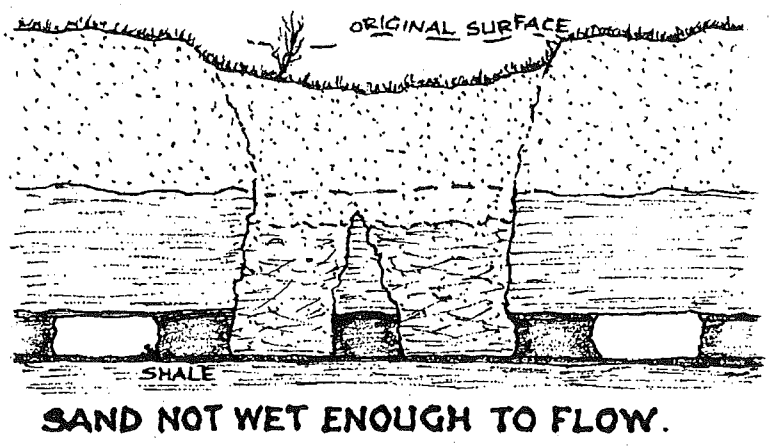


Figure 6. Roof collapse without material flow.

In loess soils and sands which is damp and cohesive, the sinkhole may have steep sides, like a chimney, whereas if it is saturated with water it may flow into the mine like liquid mud, and spread over wide areas, leaving a wide, shallow basin at surface.

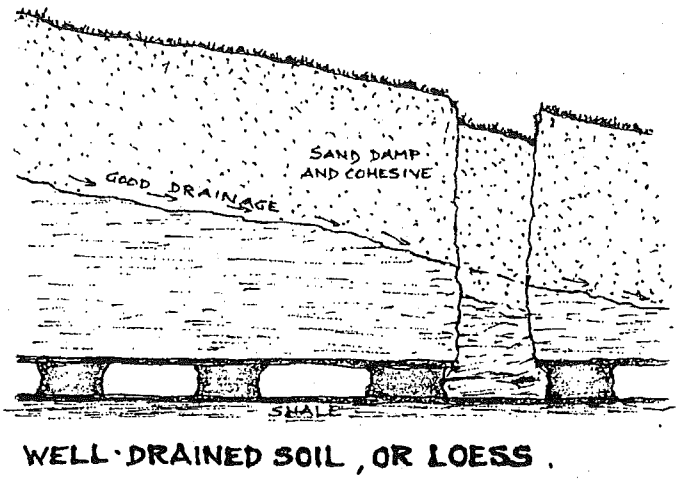


Figure 7. Development of well-defined sinkhole.

Many sinkholes have been mapped on the property, and above neighboring mines, mostly in the southern halves of the properties - where the cover is, in general, thinnest.

5. HOW DOES ALL THIS RELATE TO I-196? The relationships are debatable. Surely some day gravity will prevail and all mine openings will close - but when?

Some parts have already collapsed, we know, and for present purposes that is good. We don't have to worry about them.

Most of the mine openings stand open for tens of years, ensuring safe access and ventilation. They were designed that way, not by the textbook perhaps, but based on long experience - which is better.

Similarly the pillars were dimensioned to last for tens of years (at least until the manager responsible retires). Thirty years is a common goal.

But then what? For an answer let us look into the probable modes of failure.

Blast damage is a significant factor. High explosives in small-diameter holes not only break out the ore - they also fracture the rock, to some degree, to a depth of about 30 hole diameters into roof, pillars and floor. Thirty times 2" equals 5 ft - which would reduce a 20x20 pillar to an effective 10 x 10 ... And although the fractures may be microscopic they allow air and moisture to penetrate those members, slowly but surely, and eventually destroy them.

The thin shaley seams within the gypsum soften and yield and ooze, lubricating the joints and allowing the beds and blocks of gypsum to come apart. The measured strength of wet gypsum is about half the dry strength.

In roof and floor moisture softens shales, some to the consistency of toothpaste. That makes both roof and floor incompetent, pillars push into them, they heave into mine openings - and the system closes. It might happen suddenly, with a domino effect, in some places, but in general the movement can be almost imperceptible. In some similar mines, not flooded, it is possible to walk into old workings, with headroom, notice that the roof is getting lower, bump heads, tilt heads, stoop, support on fingertips - apelike, then kneel, crawl - and give up - with no alarming noises or actual rock falls ...

There will be some dissolution of the gypsum (which is why we get caverns and natural sinkholes) but for the most part that requires running water. Stagnant water, with no pumping, becomes saturated with gypsum then dissolution ceases.

6. S0 WHAT DO WE THINK? Our tentative conclusions are that the mine openings must someday close and allow the surface to subside, including parts of the freeway - but that some of the subsidence has already occurred, unnoticed.

Some could have occurred in the years between mining (pre-1945) and construction (1964) - around 20 years, but we do not know. Not yet.

We have procured some topo maps, dated 1984 and 1997, and a very cursory comparison suggests that parts of the freeway, at the Fulton interchange, subsided a couple of feet during that interval, and the only indication we have heard of is that one concrete slab in that area "seems to be tilted . . ." To the west of the freeway the maps appear to show as much as 6 ft of subsidence in places during that 13-year period.

A map of compared contours, Figure 8, appears at the end of this report.

The mining layout in that area, the northeast corner of the mine, is unusual. To us it looks as if it was done with coal-mining equipment, using a coal-mining layout, with rather random formation of pillars followed by slicing up those pillars with diagonal tunnels ... It looks like - and probably was - the "last hurrah" for this part of the mine, gobbling up as much as possible as quickly as possible, to move into better ground further west. We think that this area would have started to fail not long after mining.

The geology here is also noteworthy. An exploration hole (1963-2) was drilled from surface about 150 ft west of the freeway (see map) and went through 100 feet of sand and gravel but only 7 feet of rock before entering seam #2 - so apparently there was an extremely thin roof beam above the rooms and pillars and a heavy dead load on that beam - two sufficient reasons for hasty mining and departure.

That viewpoint is supported by a note on another old map, on a tract just east of the freeway, listing tons of gypsum reserves "If roof rock is present".

One more comment: the northeast corner is the lowest part of the mine, thus the first to get flooded.

Now we need to know if the tentative conclusions are correct, how much of the area under the ROW has indeed subsided, and by how much.

7. RECOMMENDATIONS.

a) That MDOT survey elevations along the freeway from Butterworth to Fulton to see how much change there has been since construction, and since the 1997 survey, and survey some E-W profiles if the changes are significant.

b) That we procure several sets of topographic maps of different ages, all on the same scale, and superimpose them to arrive at contours of subsidence for the various time intervals, and contours of total subsidence, then relate them to the rooms and pillars on the mine maps.

   We would need new, clear copies of the Abrams 1984/Domtar map, the Kent County REGIS 1997 map, USGS 1967 maps - and any others we can find. Perhaps we can get help from Uncle Sam and his satellites. If the maps were digitized the subsidence contours could be generated by computer.

c) If some doubts remain concerning the presence of voids beneath the ROW, we should have a local contractor drill half a dozen exploration holes down through the mining horizon.

d) If subsidence contour maps suggest that subsidence is continuing at significant rates, and that the surface has a long way to go, and that pillars are small in such areas - we may have to consider introducing some kind of inert mineral backfill, maybe sand, maybe flyash, into those parts of the mine - but we doubt it. Given a fair cushion of unconsolidated sand and gravel above the mine it seems that the concrete roadway can "float" around and subside without much distress - just as houses on slabs survive better in earthquake zones than do those on deep and rigid foundations.

   A possible exception to that rule may apply at the boundary of the mine, where there could be, underground, perhaps 10 ft of closure in rooms immediately adjacent to a solid abutment with zero closure - maybe a difference abrupt enough to disrupt the surface.

Jack Parker
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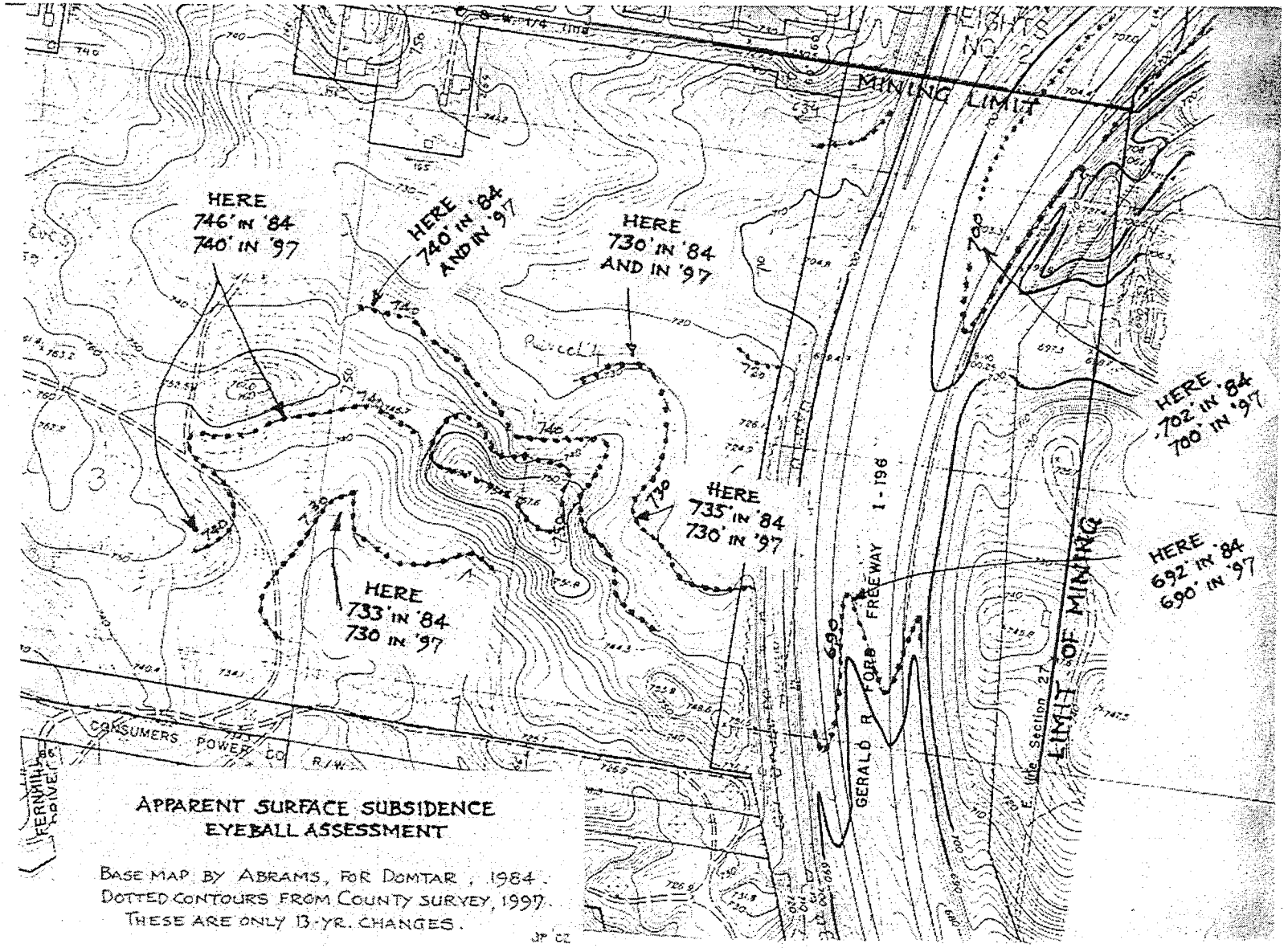

Figure 8. Comparison of elevations from 1984 to 1997.