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How Did Max Kämper and Ed Bishop Map Mammoth Cave?

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Abstract

Max Kämper made the first accurate map of Mammoth Cave showing approximately 35 miles of passages. His partner in surveying the cave was Ed Bishop, a capable caver and descendant of Stephen Bishop – the famous slave guide and explorer of Mammoth Cave. To be fair, Edmund Lee's 1835 map was a reasonably accurate rendering of the known cave at that time, which was only 8 miles. The map is a beautiful piece of cartography, but somehow he measured Mammoth Dome as being 280 feet deep, which would put it below the level of Green River. As well, Black Snake Avenue to Bottomless Pit is not shown correctly. We do not know in any detail how Max and Ed surveyed the cave so accurately. The purpose of this paper is to explore the possibilities and discuss the scant information available to us.

Introduction

Max Kämper of Berlin, Germany arrived at Mammoth Cave early in 1908, and stayed most of the year mapping the cave before returning home. Compared to New York City where he initially arrived, Mammoth Cave could only be considered remote except for one important fact: Max Eyth had visited Mammoth Cave in 1866 and drew a map of the cave. Max Eyth was a famous German engineer who had published a book in 1905 about many things including his work at Mammoth Cave (Binder 1997). Kliebhan and Thomas (2008) determined that this book was in the Kaemper family library and that Max Kämper would doubtlessly have read it. They concluded: "We do not have any doubt: Max Kaemper's journey to America was a journey on the footsteps of his idol Max Eyth, the famous engineer and poet, who's travel descriptions led the young engineer finally to the largest cave of the world." DeCroix (2008) and Sides (2008), who are also noted Kämper researchers, each concluded that Max's visit to Mammoth Cave was inspired by his famous predecessor, Max Eyth.

Over a period of only 8 months, Max Kämper made a highly accurate map of Mammoth Cave showing approximately 35 miles of passages, large and small. His partner in surveying the cave was Ed Bishop, a capable guide, caver, and relative of Stephen Bishop – the famous slave guide and explorer of Mammoth Cave. To be fair, Edmund Lee's 1835 map was a reasonably accurate rendering of the large passages known at that time, which was only 8 miles. The map is a beautiful piece of cartography, but somehow he measured Mammoth Dome as being 280 feet deep, which would put it below the level of Green River (Lee 1835). Continuing in the vein of fairness, no cave map is perfect, including Max's map. For instance, Henry's Dome and Dragon Pit are shown as different locations, but they are the same shaft. Dragon Pit especially is not easy to survey to, and errors in such gnarly passages are more likely. There were many previous mapping efforts, starting in 1810, and even beyond Max and Ed's time that showed Mammoth Cave less accurately (Brucker 2008). It should be noted that Stephen Bishop's map was drawn mostly from memory at Locust Grove near Louisville (Bullitt 1845). Realizing that,

it could have been a useful schematic for getting around in Mammoth Cave, and far better than most anyone could draw from memory.

We do not know in any detail how Max and Ed surveyed the cave so accurately. We will explore the possibilities and discuss the scant information we have. How did they measure distance, bearings, and track vertical changes? These measurements are crucial to producing an accurate survey of the cave. If there is significant error in distance or inclination measurements, then the true horizontal distance or vertical extent calculated will be wrong. More obviously, if compass bearings have significant errors, then the direction a passage is shown to run will be wrong. Distance magnifies the effect of any compass bearing error, just as slight movements while aiming a rifle result in being much further off target in a long shot. We also do not know how Max recorded data in the cave or subsequently managed the data, but presumably trigonometric calculations were done by hand, slide rule, or possibly using logarithmic tables. We do know that Max managed to render a map that is still used today by park staff to show visitors, researchers and educational groups the basic lay of the Historic Section of Mammoth Cave.

In conversation with Dr. Dieter Mucke from Germany at the 2009 International Congress of Speleology in Texas, he indicated that the Deutsches Museum in Munich, Germany had extensive information on German survey and mining technology. He pointed out that surveys in mines needed to be very accurate, and that Max's training may have included such survey skills. Interestingly, Hovey (1909) reported that Max "…came from Germany to America to acquaint himself with American manufactures and mining methods…" On this advice from Dr. Mucke, Klaus Kämper, Ulrike Schönleber (Max's grandson and granddaughter), plus Colleen and Rick Olson went to the Deutsches Museum in September of 2009. We found that there were many sophisticated survey instruments that existed far prior to Max's time, and of course ones that were available to him in his day. With the foregoing discussion as background, let us consider each of the key elements of the survey: distance, bearing, and inclination or elevation change measurements.

Distance

Hovey (1909) reported that Max Kämper told him "…that the dimensions of the cavern were too great to warrant any general method of measurement other than pacing, to which he had been trained in the military service." Brucker and Watson (1976) discussed Max and Ed's survey techniques, and reported also that Max paced the distances. Bernd Kliebhan consulted Max Kämper's obituary and verified that Max spent a year of voluntary service in the Field Artillery Regiment 3 at Brandenburg. This was after passing his exam as an engineer in the autumn of 1905. Bernd indicated that survey methods would not have been part of his training as a mechanical engineer, but that it would have been an important part of artillery training. Pacing would potentially be useful for distance measurement in those passages with level trails or those with consistent slopes. However, even in passages that are fairly level and maybe had a somewhat developed trail, if that trail undulates then the distance paced will be greater that the direct line distance. In the rough breakdown-littered passages in much of the cave (such as Grand Avenue), pacing would yield gross errors in distance measurement that would not lead to the high accuracy of the final survey. Max also clearly took data on distance to the walls, and pacing would be even more difficult with these measurements due to uneven terrain.

In the same paper, Hovey describes a visit to Violet City in November of 1908. He states that "We found it an immense expanse, measuring by the tape line 250 feet in length and 125 feet in width. . .", which clearly indicates the use of a tape measure. Everybody learns how to survey caves in part by learning how not to do it, and Max was probably no exception. The entry for May 25, 1908 in Max's journal indicates that he gave 60 cents to Ed Bishop for string and a stick. While Klaus Kamper, Bernd Kliebhan, and Chuck DeCroix worked to translate Max's journal they wondered if the string and stick were used for surveying (Figure 1). String could easily be marked at intervals with knots for distance measurement, and this technique could have been used early in the mapping effort especially in small passages where pacing was not possible. The string may also have been used to suspend a special compass or clinometer. The string and stick were purchased only a week after his suitcase (probably a trunk) arrived by freight.

Bearing

Hovey indicated in his article that Max reported "He used a good surveyor's compass in the main cave and principal branches, but relied on a pocket compass for the narrower passages and crawlways." At the Deutsches Museum in Munich we found a display of mine survey methods showing the use of a string mounted compass (Figure 2). If Max used a string-mounted instrument, then the alignment between stations was not an issue: the string held tight between stations would have defined the survey line. This could, in part, account for the high accuracy of the survey. Another major factor is competence, and Max was apparently very good at taking instrument readings. Instrument reading blunders due to variable skill level in reading instruments have plagued Cave Research Foundation (CRF) surveys, so CRF instituted back-sight readings to catch mistakes in the field. The stick and string purchased from Ed Bishop may also have served a purpose in bearing measurements. In order for the compass needle to swing freely, the compass must be very close to level. However, survey stations are rarely level with each other. The stick could have been used to space up from the floor or down from the ceiling in order to take a compass bearing between stations.

For the smaller side passages, where a larger string-mounted compass would be impractical, there were more compact

Figure 1: Klaus Kämper, Bernd Kliebhan, and Chuck DeCroix puzzle over entries in Max Kämper's journal at the Olson home during the Kämper Centennial event in October 2008.

Figure 2: A mine survey display at the Deutsches Museum showing the use of a string mounted compass.

instruments available. At the Deutsches Museum we saw a compass with fold- up alidade type sights that dated from about 1890. This type of instrument was compact and yet accurate enough to serve Max's purposes.

With the impressive array of compasses and inclinometers available to Max in Germany, we wonder if he brought such instruments with him to Mammoth Cave? Kliebhan and Thomas (2008) determined that Max departed Berlin with 155 pounds of luggage, so he was not travelling light, and survey instruments of the type we have discussed here are not very heavy.

The discussion of possible compasses used leads to the question of what kind of light he used to read the instruments without magnetic interference problems. The scene in Figure 2 shows a brass lamp being used to illuminate the compass, but we don't know if Max had such a lamp. Olson (2008) speculated that Max and Ed may have used a carbide lamp, based upon an account of a trip to Cathedral Domes by Horace Hovey (1907). Once again, Hovey's 1909 article has proved illuminating because he said "Bishop carrying an automobile searchlight for the purpose, thus giving me my first view of the wonderful and fascinating region to which has been given the name of 'Violet City'…" Auto headlights in those days were most often acetylene lamps, and Hovey had his acetylene bicycle lamp along as well. With this type of lighting it would be possible to direct light down into the compass to read it, something impossible with the iron Mammoth Cave lamps that would have also caused magnetic interference. Finally, in a letter from Albert Covington Janin to the Mammoth Cave Estate dated June 1, 1908, he describes using a carbide hand lamp in Violet City (Janin 1908). Access was via the breakdown crawl that Max and Ed first entered by, so almost certainly Max and Ed were his guides. Carbide lamps would also make mapping a large trunk passage like Grand Avenue feasible, as this would be nearly impossible in the feeble glow of the traditional Mammoth Cave oil lamps. Candles would be a simple, nonmagnetic alternative for lighting the compass. Keeping the candle lit between shots would have been challenging, or perhaps it could have been relit with a match for each shot.

Inclination or Elevation Change

Curiously, Horace Hovey did not discuss measurement of inclination in his 1909 paper. One possibility is that Max and Ed did not take inclinations, and instead kept track of elevation changes. This could have been done with the aforementioned stick that Max purchased from Ed, assuming that length increments were marked on it. This could work well in fairly level passages, but surveying through the Corkscrew with 30 meters of vertical distance between Broadway and Bandit's Hall might require more sophisticated methods. Vertical shots can be very useful in a place like Corkscrew, but where that is not possible, high angle shots may be unavoidable, and in these situations a clinometer may work best. Figure 3 is a vertical profile of the Historic Entrance vicinity and shows many steep to vertical connections between levels. In early CRF surveys, inclinations were not taken. Instead (Olson remembers this) they estimated changes in elevation. Problems resulting from this method led to the adoption of vertical angle measurements when Suunto instruments became available. Hovey reported that Max "…had taken no barometric observations", so we can rule out this method, which is of doubtful precision under the best of circumstances.

In the mining section display at Deutsches Museum, one of the survey team members was holding a string–mounted inclinometer. This was a very reliable way to measure angles up and down. In the Visitor Center museum at Dachstein Mammuthöhle in Austria, we also saw an old string-mounted inclinometer on

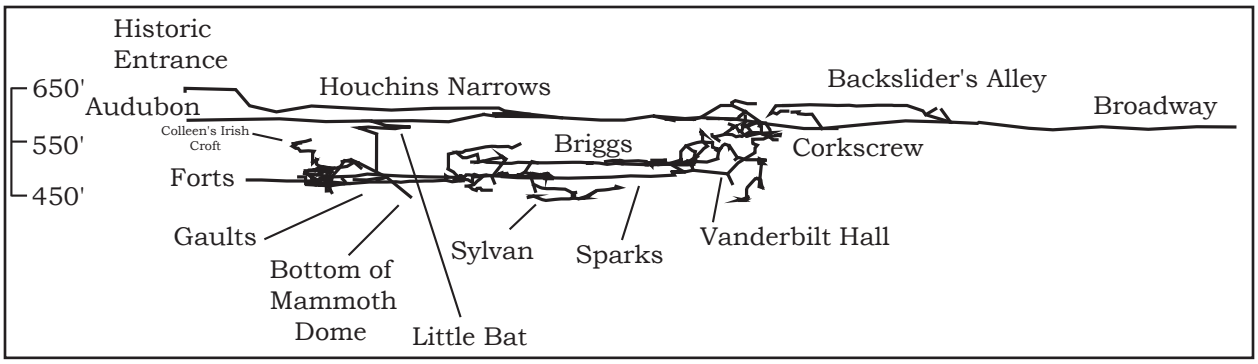

Figure 3: A vertical profile of the Historic Entrance area based upon modern survey data. Courtesy of Ed Klausner, CRF.

display, so these were perhaps not rare in Max's time. In the cartography section of the Deutsches Museum, we found two compact hand held inclinometers on display, so instruments of this type would also have been available to Max (Figure 4).

Survey Station Labeling

In order to avoid mistakes in reading from one station to the next, and especially for tying survey lines to each other, it is important to mark stations in some manner. In portions of the cave where Max and Ed surveyed, we had noticed stations marked in yellow and orange crayon. The station labels consisted of a number with a # sign, and in some places there were short wooden stakes. We wondered if these were Max and Ed's stations until we realized that this numbering system was used along the route from Roaring River to New Discovery by Park Engineer Paul McG. Miller and teams working under him in the late 1930s. To date, we do not know how Max and Ed Marked survey stations.

Accuracy Assessment

There were two primary ways for Max to assess the accuracy of their survey. First, were survey loops within the cave. When the survey line ties back into itself, ideally the tie stations will plot right on top of one another. As a practical matter this does not happen with compass surveys, and instead the hope is that the error is within reason. According to Max's journal, they mapped Gothic Avenue on March 11, Corkscrew on March 15, and Lost Avenue on March 19. The journal does not provide a complete record of mapping activity, so presumably the survey of Gothic Avenue was followed by Gratz Avenue and Wilson's Way, so that when Lost Avenue and Harvey's Way were surveyed, a loop was completed via Main Cave at Acute Angle to Booth's

Figure 4: Hand- held inclinometers from Germany were on display in the cartography section in the Deutsches Museum. The one shown was made in Munich around 1860, and with this instrument it would be possible to align the case along a string between stations or use the flip-up alidade sights.

Amphitheater. According to Max's Journal, he was at Annetta's Dome at the end of Gratz Avenue with Judge Janin on April 26, but it does not say they were mapping. In similar fashion, the Corkscrew survey would tie into the Historic Tour route above at Kentucky Cliffs and below at Bandit's Hall. On March 20 and 21 they mapped Fort's Way and Gault's Way off Mammoth Dome, and these passages would make a nice loop useful for accuracy assessment. An even bigger loop would have been Mammoth Dome and the end of Little Bat Avenue, which they knew connected. Other loops were certainly completed, but these were likely the earliest in the mapping effort and would have given Max an idea of how accurate the survey was and whether modifications to the survey methods were needed.

The second way for Max to check accuracy was via sound connections between different parts of the cave that the map showed to be close to each other. From the survey it was clear that Sandstone Avenue and Violet City were very close, but no previous maps indicated this proximity and the veracity of this was apparently questioned. In a letter to Judge Janin dated August 4, 1908, Max informs him that Violet City is 1.36 miles in a direct line from the hotel and that the end of Sandstone Avenue is 1.40 miles at a bearing of 26 degrees east of south (154°) without consideration of "declension" (declination) because he did not know what it would be in Kentucky. He finishes by saying "Every other statement is idle talk without any better proof than void guessing!" That these passages were indeed close was verified, probably on July 1 according to Max's journal entries, with Ed Bishop in Sandstone Avenue and Max with Norman Parrish in Violet City. According to Hovey (1909), they first fired revolvers, which were inaudible, and then pounded on the walls, which could be faintly heard. Hovey's short article also mentions two other sound connections. A pounding test was conducted where Wright's Rotunda crosses over Serpent Hall, and verified the accuracy of the map at that point. Finally, Hovey reported that "while we stood in Chief City, we plainly heard the steam cars running overhead along the Mammoth Cave Railroad." This would be a less informative test of accuracy due to the ability of the train sounds to travel farther than the sound generated by hand pounding. However, if Max ran a spray line off one of his surface survey lines to where Chief City was located according to his cave survey, then the proximity of the rail line to Chief City could have been demonstrated. Indeed, one of us (Toomey) pulled up the map showing Chief City and the overlying former rail line, and the two features are almost perfectly coincident along a north-south axis. Therefore, the rail line would have been most useful along an east-west axis for accuracy assessment.

A final possible way that they may have been able to check accuracy was the result of an unintended event. After pounding demonstrated the proximity of Sandstone Avenue and Violet City, they attempted to connect them by blasting on the Violet City side. They did not connect the two passages, but did come very close to reaching the surface (Hovey 1909, Meloy 1975). This surface site was known to Max and Ed, so they could have surveyed overland from the Historic Entrance to close a large survey loop. We do not know if they did this, but it is something that could have occurred to them, and we do know that they conducted surface surveys to ascertain how the cave and property lines related. Violet City is a long survey run from Historic Entrance, and so having another surface tie would be extremely attractive.

The modern CRF survey of Mammoth Cave has had the benefit of many decades of work and reworking of the map, many entrances that provide control points to detect significant errors, cave radio

locations in passages remote from any entrances, computerized distribution of survey error, dozens of survey teams, and so on. Max did not have much time, and he had only one entrance plus one possible blast site with surface disturbance at Violet City that he and Ed could have used as an additional control point. With these facts in mind, we compared Max's map with the current CRF survey, and the results were really quite good as can be seen in Figure 5.

Scale and Orientation

No scale or north arrow was put on the map because it was for private use of the Mammoth Cave Estate, and in case the map should fall into the wrong hands then competitors could not easily tell which passages extended beyond estate property lines. However, in a December 7, 1908 note, Max provided this information in his own hand, written on stationery from the Raleigh Hotel in Washington DC. It is copied here in italics:

> ***Key to the Map of the Mammoth Cave.***
>
> *The arrow at the entrance points due South East. The little circle in the Rotunda shows the point where on surface is the corner in the angle of the Hotel. (Pinson's Office)*
>
> *From this point as a basis a due S.E. line is drawn, which forms an almost exact center line to the main course of the cave. This line is indicated by a sequence of little circles, ½ mile distant from each other, thus giving at the same time the scale of the map, which is 20 cm. to ½ m. The full –mile points are indicated by a small circle inside a slightly bigger circle (shown graphically in the note).*
>
> *1 mile point near "Burleys Way"*
>
> *2 " " " "Hell Hole"*
>
> *3 " " " "Blairs Dome"*

Conclusion

In summing up, we can say that Max Kämper's visit to Mammoth Cave was likely no accident and instead was inspired by the famous German engineer, Max Eyth, who had mapped Mammoth Cave and written about it in a book that Kämper almost certainly read. We know that underground survey techniques for mining in Germany were highly developed, and that there were an array of compact but accurate compasses and inclinometers available. Given that he was following in the footsteps of Max Eyth, Max Kämper may have brought suitable survey instruments with him. The question of distance measurement is somewhat confused by Hovey's report of pacing and also of the use of a measuring tape. The usefulness of pacing would have been limited to places with nearly planar floors, and where walking was possible. These criteria eliminate much of the cave Max and Ed surveyed. This problem would be manifest in both measuring distances from station to station, and also in measuring to the walls from a given station. We know that Max and Ed checked the accuracy of the map in at least two places: Wright's Rotunda/Serpent Hall, and Violet City/Sandstone Avenue. Blasting to connect these latter two passages may have given them another surface control point at Violet City in addition to the only other one: the Historic Entrance. Max Kämper's map compares favorably with the modern CRF map in the Violet City and Cleveland Avenue area.

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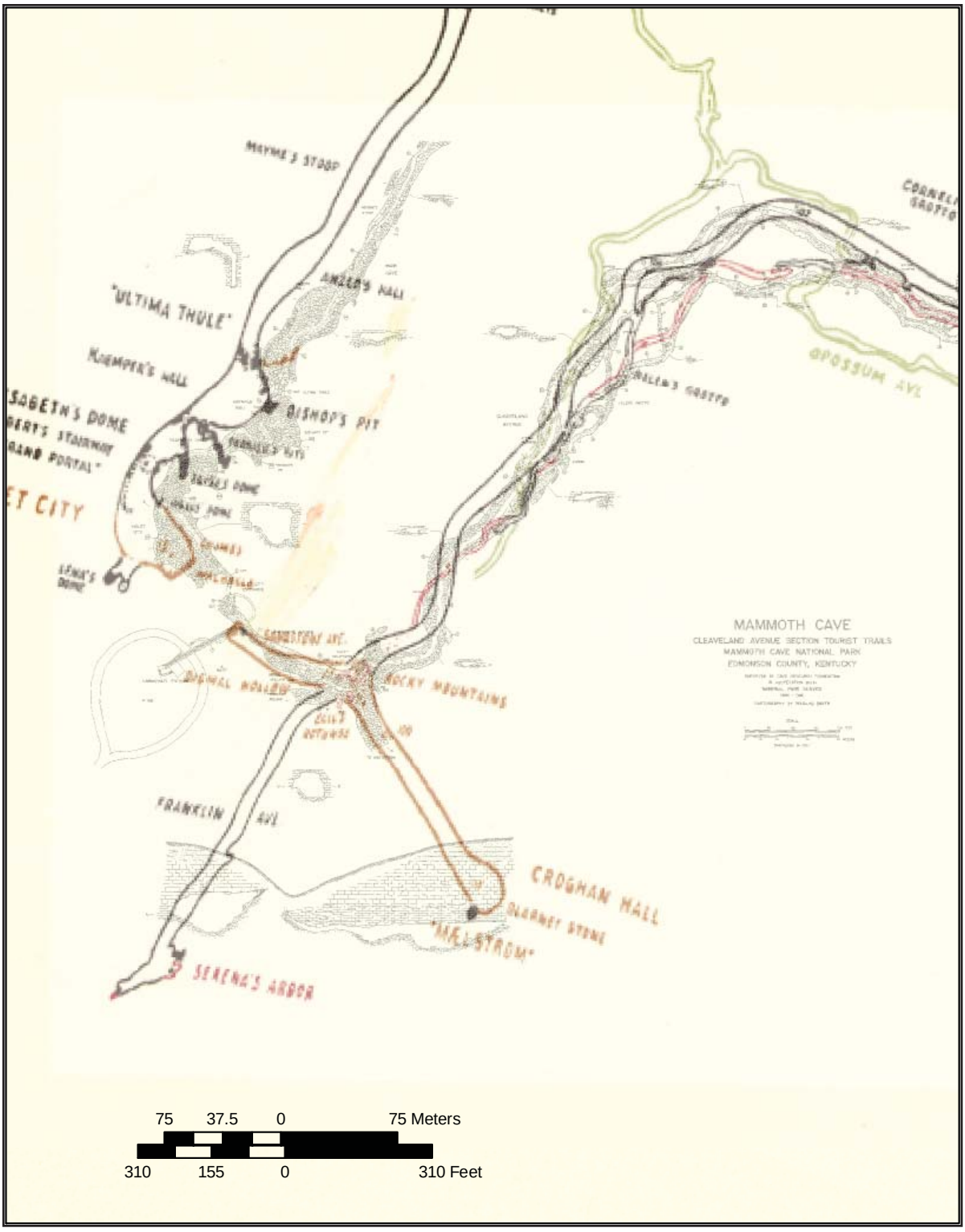

Figure 5: Overlay of Max Kämper's map on the current CRF map by Rick Toomey. Overlay was created in Arc View using only two registration points for the Kämper map: Historic Entrance (TT1WAZ) and Ste. Catharine City (TT7W).

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