

Historical Archaeology of the Hannibalic Invasion of Italia: Technical Applications

William C. Mahaney, Michael W. Milner, Barbara Kapran, Pierre Tricart, Stephane Schwartz, Rene W. Barendregt, David H. Krinsley, Ronald I. Dorn, Barbara Trapido-Lurie, Sal Boccia, Rana N.S. Sodhi, Volli Kalm, and Roelf Beukens

ABSTRACT

Previous attempts to plot the exact invasion route of the Punic army in 218 B.C. have been limited, with one exception (de Beer 1967, 1969), to analysis of topography and previous historical arguments based on the interpretation of classical texts written by Polybius and Livy. Eliciting environmental information from classical literature led to a focus on environmental landmarks, including the rockfall that blocked the army on the lee side of the Alps, a firing event described by Livy, and the regrouping area where the army rested after conflict with the Gauls and the trek over a major col of passage into Italia. The use of various scientific methods to analyze these three major sites/events has led to a conclusive identification of the invasion route, and sites of interest to geoarchaeologists.

Introduction

The Punic invasion of Italia in 218 B.C. has been investigated within the domain of classical history for over two millennia, but almost completely overlooked by geoarchaeologists. Eliciting environmental information from ancient texts has recently prompted four expeditions to survey the approach routes through the Pyrenees and the Alps (Figure 1), a research effort that has led to the identification of sites of interest to historical archaeologists (Mahaney 2004, 2008, 2009; Mahaney and Tricart 2008; Mahaney et al. 2008a, 2008b). Previous attempts to identify the invasion route (from among the three proposed routes shown in Figure 1) and ultimate col of passage by Hannibal into Italia (de Beer 1969; Proctor 1971; Bagnall 1999; Lazenby 1998; Lancel 1999) relied on historical precedent, time/motion analysis, and topographic assessment. A detailed analysis of environmental parameters, critical to identifying not only the route, but key areas

where artifacts might be recovered, started with Mahaney (2004, 2008, 2009).

This overview of the historic context and scientific techniques used in recent efforts to assess potential routes focuses on three critical aspects of the invasion: (a) a two-tier (doublet) rockfall that blocked Hannibal's army on lee side of the Alps, (b) an assessment of the firing event in which Hannibal is said to have used fire to break up bouldery debris in the rockfall, and (c) a regrouping area after construction of a road through the rockfall. The key topographic landmark to identifying the correct route of passage is the two-tier rockfall described by Polybius (1979). As discussed below, the only two-tier deposit is located below the Col de la Traversette on the southern route. The methodology applied in this study is transferable to other historical archaeology projects in which composition and age of materials provide the hinge upon which all relevant archaeological investigations might be expected to proceed.

Sites

Identification of sites of interest to historical archaeology is based on an evaluation of environmental parameters deduced from the ancient literature, principally from Polybius (1979) and Livy (1972). These analyses involve the identification of a major defile where the Punic army was engaged by the Gauls (Mahaney and Tricart 2008), various camping/bivouac areas on either side of the Alps, the high col capable of sustaining snow and sporadic permafrost, a major rockfall blocking egress of the army on the Italian side, the possibility of a fired rock outcrop, and a regrouping area within sight of the rockfall. All of these sites are described, analyzed, and discussed in the sources outlined above. Three of these, in particular (a) the rockfall, (b) the fired rock out-

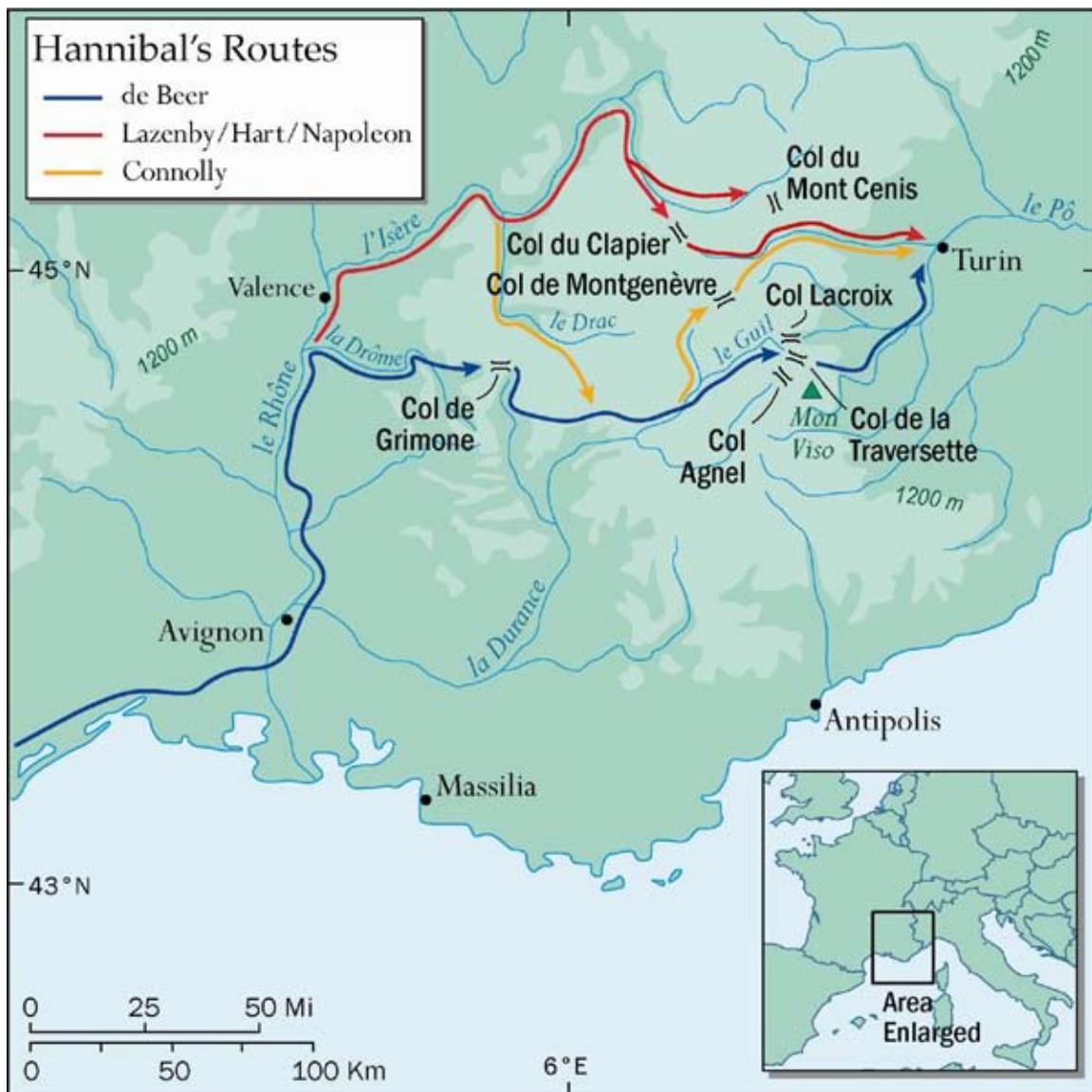


Figure 1. Proposed invasion routes into Italia as documented by various authorities (Mahaney 2009). Used with permission.

crop, and (c) the regrouping area, are critical to identifying the route and selecting sites with potential for exploratory archaeology that might shed considerable light on the military culture of ancient Carthage.

The rockfall described by Mahaney (2008, 2009) is the most prominent mass of rock rubble existing beneath any of the major cols that historians consider likely candidates for Hannibal's passage over the Alps (Figure 2). No other geomorphological feature matches the rock mass at 2,600 m above sea level (ASL) in the upper Po River drainage below the Col de la Traversette. All cols have rockfalls of some volume, but none are of a size that would have stopped

Hannibal's army (Mahaney 2008, 2009). Moreover, the rubble sheet, as described by Polybius some sixty years after the invasion, is a two-tier event (Polybius 1979) consisting of an older deposit covered by a more recent mass of cover sediments. The rockfall below the Traversette is the only such mass-wastage deposit seen below major cols in the Cottian Alps. The older, more voluminous deposit is of probable Late Glacial age (± 10 ka) while the younger, thinner mass is of probable mid-Neoglacial age ($\pm 1-3$ ka) (Mahaney 2008, 2009).

The fired rock outcrop below the Col du Clapier, 60 km north of the Col de la Traversette, is important prin-



Figure 2. Traversette rockfall with two-meter thick mass of surface sediment visible above the break in snow cover (Mahaney et al. 2008). Used with permission.

cipally because Livy (1972) states that a “landslide” blocked Hannibal’s army. Livy claimed that Hannibal resorted to firing the boulders in the mass to split them, making it easier for his soldiers to construct a path that would accommodate his elephants, horses, and other draft animals. The only col with burnt rock lies below the Clapier Pass (Mahaney et al. 2007), and significant analysis has been carried out on samples from this mass to attempt to determine composition, firing temperature, and age.

The regrouping area below the Col de la Traversette was deemed worthy of exploratory geoarchaeology to determine if artifacts can be recovered. The location is a grassy meadow with minor rockfall material, significant forage and water supplies, and sunken walls of some antiquity, given the lichen cover on the boulders.

Methods

Weathering and soil measurements follow Birkeland (1999). Lichen measurements are based on methods outlined in Mahaney (1990, 1991) and Spence and Mahaney (1988). A high-resolution field emission scanning electron microscope (FESEM) and an energy-dispersive spectrometer (LINK-ISIS) were used to image samples and recover chemistry (Mahaney 2002). Raman spectroscopic analysis was carried out at the École Normale Supérieure, Lyon, France, using a Horiba Jobin Yvon spectrometer, model

Labraim h.r. 800. High-resolution transmission electron microscopy (HRTEM) and back-scattered electron microscopy were employed to complement these strategies.

Results

The Rockfall

Calculations of the geometry of the rockfall place the volume at between 50,000 and 75,000 m³, making it one of the largest mass-wastage deposits below any of the cols of passage in the Cottian Alps. The composition of the bedrock in the source area of the rockfall is carbonaceous mica schist and metabasalt. Weathered regolith (soil) emplaced along the exit route is classified as a cryorthent (Birkeland 1999), with an Ah/Cox/D profile. This soil exhibits a profile that can be dated by relative-age criteria with respect to depth, physical and chemical characteristics, and degree of development, to the mid-Neoglacial (1–3 ka), approximately within the Hannibalic timeframe. The physical characteristics of the soil, color changes with depth, and lack of appreciable clay-size material, are consistent with other well-documented, mid-Neoglacial (1–3 ka) mountain soils (Mahaney 1991). X-ray diffraction (XRD) analysis of the clay fraction indicates mainly quartz, plagioclase, and chlorite, with very minor amounts of vermiculite, all indicative of young soils.

Attempts to reconstruct the shape of the cover sediments in Hannibal's time by using lichen trimlines, as used elsewhere by Mahaney (1987), were not successful because the lichen cover and maximum diameters of *Rhizocarpon* Section *Rhizocarpon* on bedrock outcrops adjacent to the cover sediments are at longevity. The lifespan of lichen species here is between 2 and 3 ka, using approximations of lichen growth on Mount Blanc (80 km to the north) and other well-documented, middle-latitude areas, but is not known with precision. Weathering characteristics (pits and secondary oxides) are uniform on bedrock exposures adjacent to the upper rockfall, and do not allow identification of discrete source rock for the two deposits. The bedrock adjacent to the rockfall that provided source material is metabasalt at base, overlain with carbonaceous mica schist, which is largely consistent with the mineralogy of the two deposits.

The lack of suitable organic remains in the rockfall limits the application of radiocarbon dating in this instance. There are no trees present within or near the rockfall at present. A search of fine material in the soil matrix did not reveal seeds of forest species, or even partial nut shells or pits brought along as food by the Carthaginians. Further analysis of the fine soil matrix for resin amber was unsuccessful. Pollen analysis (Christopher Carcaillet 2008, pers. comm.) indicates the rockfall was likely covered with a thin distribution of boreal forest species, which correlates well with XRD analysis of the rockfall soil, since vermiculite is a known indicator of evergreen forest cover (Birkeland 1999).

Firing Event

The fired rock outcrop below the Col du Clapier is important to assess since Livy, probably relying on other authorities no longer available to us, documents that Hannibal spent considerable time firing boulders to forge a passage through the blocking mass. Polybius is mute on this subject, and since Polybius is considered by most historians to be the more reliable source (de Beer 1969; Lancel 1999), the firing event may in fact be a fabrication (Mahaney 2008, 2009). The very existence of the fired rock outcrop, however, demands investigation and the determination of its age. Samples of fired rock collected in 2004 were submitted to the Isotracer Laboratory at the University of

Toronto for Accelerator Mass Spectrometry (AMS) dating. Insufficient carbon was recovered from thin (approximately 500 nm), carbonized, rock chips collected at the fired rock site, making it impossible to determine an AMS ^{14}C date range. Thus, the radiometric age of the rockfall remains elusive (Mahaney et al. 2007).

The relative age of the fired crust, however, based on a lack of weathering rinds on outcrops and overall uneven distribution of small, maximum diameters (<20 mm) of *Rhizocarpon* Section *Rhizocarpon*, indicate the firing event is likely recent, perhaps no more than a century old. Despite the presence of a carbon source which ought to spur lichen growth, the small sizes of lichen thalli and low cover (<1%) suggest the fired site is unrelated to Hannibal.

Composition of the fired amphibolite schist was determined using the FESEM and energy dispersive spectrometer (EDS) (Mahaney 2002) and secondary ion mass spectrometry (ToF-SIMS) (Mahaney et al. 2007; Sodhi, Mahaney, and Milner 2006). The FESEM analysis showed the thickness of the fired mat to vary from <100 to approximately 500 nm, with numerous microfractures to depths of several microns, presumably the result of the conflagration that weakened the outer rock fabric, a brecciated amphibolite (Figure 3a). Tonal contrast in the image does not indicate the chemistry, though carbon is present in the micro-ruptured area. The burnt (carbonized) rim is clearly different from the micro-ruptured breccia zone below, which suffered only minor carbonization. The carbon coating on the rock face contained frequent fungi of rather large dimensions (2–3 μm in diameter), which raises the question of how long microbes take to colonize a fired rock outcrop.

A comparison of non-fired and fired amphibolitic schist by ToF-SIMS showed the normal range of silicon, aluminum, manganese, sodium, and calcium in both samples, with elevated amounts of potassium, carbon, carbon-hydrogen and carbon trioxide lacing the surface and part of the brecciated layer. The presence of potassium and carbon trioxide on the burnt crust and within fissures is a clear indication of the presence of wood ash from burning timber. If the fire had been started with gasoline as an accelerant, these residues would not be present. Firing also caused the geochemical mobilization of surface rock elements sodium, calcium, and chlorine (Sodhi, Mahaney, and Milner 2006). This leads to the postulation that the fired crust may be the product of

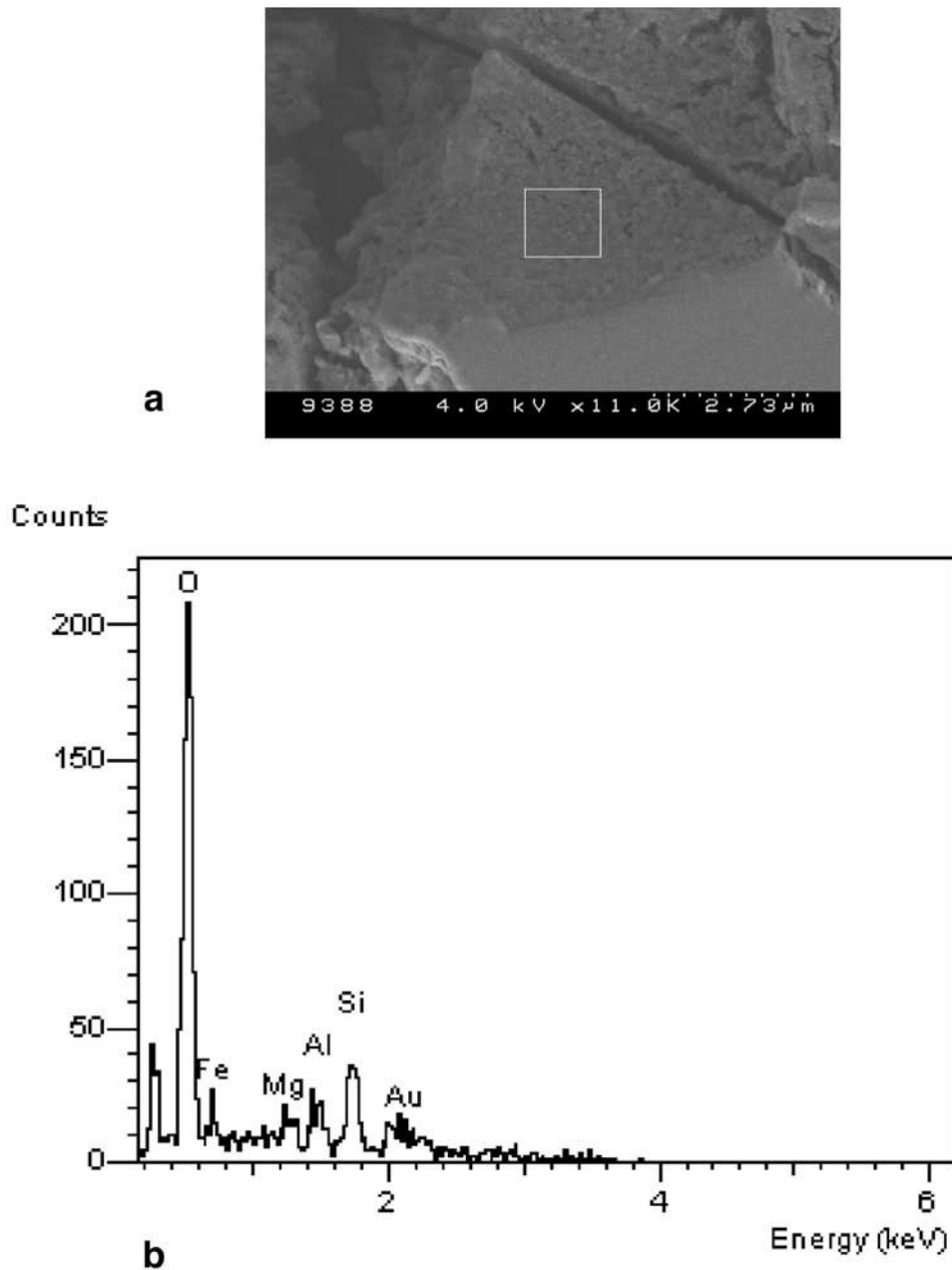


Figure 3. a: FESEM image of burnt area with square in center. b: Epoxy boundary of polished section is outlined below; b, Chemistry at 4 kv shows high carbon and oxygen content.

a lightning strike, although magnetic investigations do not conclusively point to this agent. Determination of Koenigsberger ratios (ratio of remnant magnetization of a rock sample to the magnetization induced by the earth's present magnetic field) yield values which are just below the threshold value of lightning-affected rocks (Mahaney et al. 2007).

Firing induces the solid state transformation of organic matter into carbonaceous material (graphitization), producing the clearly observed patinas seen in the field. Raman spectroscopic analysis of samples from the Col du Clavier showed the graphite band (G-band), which corresponds to the normal vibration mode of aromatic carbons in the graphite structure. Wider bands more dif-

fuse than the G-band are the result of structural defects, or the presence of heteroatoms of oxygen, hydrogen, and nitrogen (Beysac et al. 2002). The Raman spectra provide a geothermometer of maximal temperatures reached during conflagration, which in this case yields a temperature of approximately 360°C, consistent with a low-temperature brush fire. This is consistent with the present environmental setting of the fired rock outcrop at 1,693 m ASL, 45°9' N, 6°56' E, in the northern Cottian Alps of Italy.

High-resolution TEM (HRTEM) analysis of the burnt rock shows carbon infusing into quartz in the schist (Figure 4). The carbon is interpreted to be in the form of graphite. Cohen-Ofri (2006) analyzed the structures and composition of modern and fossil charcoal at archaeological sites. Over time, charcoal underwent diagenesis into graphite-like microcrystallites and non-organized phases. In the present study, similar features were observed on quartz surfaces, where most of the charcoal was in a non-organized phase, but there were islands of more organized, graphite-like, microcrystallite features (Figure 4).

Regrouping Area

The regrouping area described by both Polybius (1979) and Livy (1972) lay somewhere below the rockfall, not at a great distance, but certainly with forage for the animals and water for the army. The soldiers could thread their way through the rockfall, but Hannibal's engineers had to construct and ballast a path of some substance (approximately 225 m in width) in order to allow passage of the horses, elephants, and baggage train. The army bivouacked for a period of three days, which must mean there is likely to be a higher frequency of artifacts in the regrouping area than at the rockfall and along the fired path, if the firing locality exists (Mahaney et al. 2007). Between 2,000–1,850 m ASL, lush alpine meadows stretch down the mountain adjacent to the upper Po River. Below the 2,000 m waterfall, a series of sunken walls, well covered with lichen growth as shown in Figure 5, offer the possibility that they were used or built by Hannibal during the path construction through the rockfall.

No excavations were carried out at the regrouping area as exploratory work would require an archaeologist

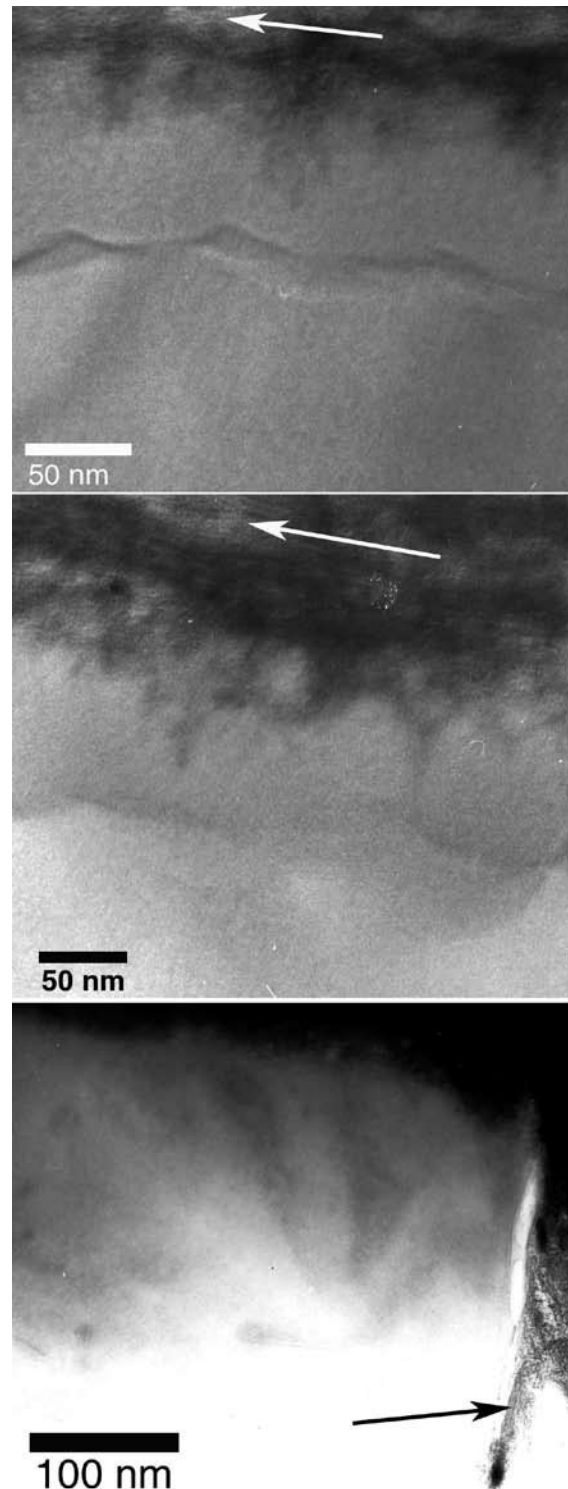


Figure 4. High resolution TEM images of the interface between graphite and the underlying quartz. Arrows indicate the more organized phases of graphite-like microcrystalline domains, whereas the darker areas are non-organized phases that display an irregular boundary with the quartz.

with a license to collect. The site carries a fluvisol (alluvial soil with an A/C profile) of some antiquity, however, probably dating to well before the invasion. An inspection of the stream cuts did not reveal any charcoal fragments that might be correlated to the firing event described by Livy. Likewise, inspection of the rockfall did not reveal any evidence of firing. Lastly, a brief magnetic detector survey of the sunken walls (2008) did not produce significant results. A more exhaustive search may well reveal sites where exploratory geoarchaeology is warranted, however.

Conclusions

Reconstruction of ancient historical events after the analysis of key environmental data in classical texts has led to the identification of sites of importance to historical archaeologists. Using a number of different scientific methods—geomorphological, geological, geophysical, and chemical—to study key localities and samples recovered from surface deposits and rock outcrops, it is possible to identify specific areas where geoarchaeological exploration may reveal important information on the forays of ancient Carthage into Italia.



Figure 5. Lichen cover in the regrouping area typical also of the rockfall. Cover is estimated at 70%. Maximum lichen diameters are in the range of 50 mm. The large lichen in the center is an amalgam of *Rhizocarpon* Section *Rhizocarpon*, probably two or more species coalescing from several discrete thalli. The yellow thalli with black fruiting bodies is likely *R. geographicum*, the famous circumboreal lichen used extensively for dating geomorphological features (Mahaney 1990, 1991).

The main evidence used to pinpoint the route shown in Figure 1 is the two-tier rockfall described by Polybius over two millennia ago. A search of all relevant cols of passage for the Punic army led to an identification of the only two-tier rockfall deposit in the Cottian Alps on the scale described by Polybius. There are rockfalls on or around all the other cols, but none are of a relevant scale, nor are they doublets and of an age that coincides with the invasion. The firing event at the only carbonized outcrops along one of the northern routes is judged on a lichenometric basis to be too recent to match the time and place of the firing event described by Livy. This provides evidence which argues against Hannibal's use of the northern route favored by some historians. Lastly, the regrouping area below the Col de la Traversette rockfall in the upper Po catchment is of a size, with the necessary forage and water requirements described by both Livy and Polybius, to match the descriptions in the ancient literature. From this and other evidence collated and discussed by Mahaney (2009), the ancient enigma of the invasion route can be put to rest. Hannibal followed the path laid out in great detail by Sir Gavin de Beer, who summarized all historic documentation as well as detailed topographic information to argue for the southern route through the Col de la Traversette into the upper Po River valley.

ACKNOWLEDGMENTS

We gratefully acknowledge funding from Quaternary Surveys, Toronto. We also appreciate critical reviews from two anonymous reviewers.

REFERENCES

- Bagnall, Nigel
1999 *The Punic Wars*. Pimlico, London, UK.
- Beysac, O., B. Goffé, C. Chopin, and N. Rouzaud
2002 Raman Spectra of Carbonaceous Material in Metasediments: A New Geothermometer. *Journal of Metamorphic Geology* 20(9):859–871.
- Birkeland, Peter W.
1999 *Soils and Geomorphology*. Oxford University Press, Oxford, UK.

- Cohen-Ofri, I., L. Weiner, E. Boaretto, G. Mintz, and S. Weiner
 2006 Modern and Fossil Charcoal: Aspects of Structure and Diagenesis. *Journal of Archaeological Science* 33(4):428–439.
- de Beer, Gavin
 1969 *Hannibal*. Viking Press, New York, NY.
- Lancel, Serge
 1999 *Hannibal*. Blackwell, Oxford, UK.
- Lazenby, John F.
 1998 *Hannibal's War*. University of Oklahoma Press, Norman.
- Livy
 1972 *The War with Hannibal*, Aubrey de Séincourt, translator. Penguin, London, UK.
- Mahaney, William C.
 1987 Lichen Trimlines and Weathering Features as Indicators of Mass Balance Changes and Successive Retreat Stages of the Mer De Glace in the Western Alps. *Zeitschrift für Geomorphologie* 31(4):411–418.
- 1990 *Ice on the Equator*. William Caxton, Ellison Bay, WI.
- 1991 Later Pleistocene and Holocene Glacial Chronology at Chamonix and Argentière, French Alps. *Zeitschrift für Geomorphologie* 35(2):225–237.
- 2002 *Atlas of Sand Grain Surface Textures and Applications*. Oxford University Press, Oxford, UK.
- 2004 A Geological/Topographical Reconnaissance of Hannibal's Invasion Route into Italia in 218 B.C. In *Studies in Military Geography and Geology*, D.R. Caldwell, J. Ehlen, and R.S. Harmon, editors, pp. 67–78. Kluwer Academic Publishers, Dordrecht, The Netherlands.
- 2008 The Alpine Invasion of Italia in 218 B.C.: Geological Reconnaissance of the Alpine Route. *American Journal of Ancient History*, New Series 6, in press.
- 2009 *Hannibal's Odyssey: Environmental Background to the Alpine Invasion of Italia*. Gorgias Press, Piscataway, NJ.
- Mahaney, William C., and Pierre Tricart
 2008 Hannibal's debacle in the Combe de Queyras in 218 BC: The unknown Gallic Commander. In *Military Geography and Geology: History and Technology*, C.P. Nathanail, R. Abrahart, and R. Bradshaw, editors, pp. 88–97. Land Quality Press, Nottingham, UK.
- Mahaney, William C., Michael W. Milner, Rana N.S. Sodhi, Ronald I. Dorn, Sal Boccia, Roelf P. Beukens, Pierre Tricart, Stephane Schwartz, Eva Chamorro-Perrez, Rene W. Barendregt, Volli Kalm, and Randy W. Dirszowsky
 2007 Analysis of burnt schist outcrops in the Alps: Relation to historical archaeology and Hannibal's crossing. *Geoarchaeology* 22(7):797–816.
- Mahaney, William C., Volli Kalm, and Randy Dirszowsky
 2008a The Hannibalic Invasion of Italia in 218 B.C.: Geological/Topographic Analysis of the Invasion Routes. In *Military Geography and Geology: History and Technology*, C.P. Nathanail, R.J. Abrahart, and R.P. Bradshaw, editors, pp. 76–86, Land Quality Press, Nottingham, UK.
- Mahaney, William C., Volli Kalm, Randy W. Dirszowsky, Michael W. Milner, Rana N.S. Sodhi, Roelf Beukens, Ronald I. Dorn, Pierre Tricart, Stephane Schwartz, Eva Chamorro-Perez, Sal Boccia, Rene W. Barendregt, D.H. Krinsley, E.R. Seaquist, David Merrick, and Barbara Kapran
 2008b Hannibal's Trek Across the Alps: Geomorphological Analysis of Sites of Geoarchaeological Interest. *Journal of Mediterranean Archaeology and Archaeometry* 8(2):39–54.
- Polybius
 1979 *The Rise of the Roman Empire*, Ian Scott-Kilvert, translator. Penguin, London, UK.
- Proctor, Dennis
 1971 *Hannibal's March in History*. Oxford University Press, Oxford, UK.

Sodhi, Rana N.S., William C. Mahaney, and Michael W. Milner
2006 ToF-SIMS Applied to Historical Archaeology in the Alps. *Applied Surface Science* 252(19):7140–7143.

Spence, John R., and William C. Mahaney
1988 Growth and Ecology of *Rhizocarpon* Section *Rhizocarpon* on Mount Kenya, East Africa. *Arctic and Alpine Research* 20(2):237–242.

William C. Mahaney

Michael W. Milner

Barbara Kapran

Quaternary Surveys
26 Thornhill Ave.
Thornhill, ON, Canada L4J 1J4

Pierre Tricart

Stephane Schwartz

Laboratoire de Géodynamique des Chaînes Alpines
University of Grenoble
Observatoire des Sciences de l'Univers
38041 Grenoble, France

Rene W. Barendregt

Department of Geography
University of Lethbridge
Lethbridge, AB, Canada T1K 3M4

David H. Krinsley

Department of Geological Sciences
University of Oregon
Eugene, OR 97403-1272

Ronald I. Dorn

Barbara Trapido-Lurie

Department of Geography
Arizona State University
Tempe, AZ 85287-0104

Sal Boccia

Department of Materials Science
University of Toronto
Toronto, ON, Canada M5S 3E4

Rana N.S. Sodhi

Surface Interface Ontario and Department of Chemical Engineering
University of Toronto
Toronto, ON, Canada M5S 3E5

Volli Kalm

Institute of Geology
Tartu University
Tartu, Estonia 51014

Roelf Beukens

IsoTrace Lab
Department of Physics
University of Toronto
Toronto, ON, Canada M5S 3E5