THE CO-PRODUCTION OF *TERROIR* IN A HUNGARIAN WINE REGION:

A SCIENCE AND TECHNOLOGY STUDIES (STS) APPROACH TO THE MINERALITY CONCEPT IN VITICULTURE

by

A. JUNE BRAWNER

(Under the Direction of Jennifer Jo Thompson)

ABSTRACT

Terroir, or "the taste of place" (Trubek 2008), is the unique assemblage of environmental and cultural factors that define a particular geography, essentialized in the food products of that region. Empirical accounts of *terroir* are debated in environmental sciences (e.g. Gladstones 2011), yet the elusive *terroir* is given legal expression through policies such as Geographical Indications (GIs) (Josling 2006).

This paper uses the STS *idiom of co-production* (Jasanoff 2004) to account for the meeting of material landscapes and ideologies in the production of post-socialist *terroir* wines using a case study from the world's second oldest GI: the Tokaj wine region in Hungary (1737). Following a village-level initiative to (re)brand this once-renowned wine region, which hinges on distinction through *soil minerality*, I ask: How is soil science (and its methodologies) deployed in the reification of *terroir,* making ideologies of difference material features of landscapes? This question is answered using a mixed methods approach in Tokaj, Hungary and employ the idiom of co-production (Jasanoff 2004) to contextualize soil science as a socio-political enterprise.

INDEX WORDS: Science and technology studies, terroir, soil science, viticulture, post-socialism.

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DEDICATION

In memory of Grandma, who taught me how to get my hands dirty.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

GEOGRAPHY OF THE CARPATHIAN BASIN

I. INTRODUCTION

In food crops, the assumed link between geographies of production and the qualities of resulting products is perhaps as old as agriculture itself; this is nowhere else so visible as in winemaking, where *terroir*—or the *taste of place*—is thought to be an essential, irreproducible feature of geographically-anchored wine grapes. Today, the *terroir* concept in winemaking ranges from mythological to legal to techno-scientific. Forming the basis of protectionist policies that regulate food origins, it lies at the nexus of human and ecological systems. In this thesis, I use a science and technology studies approach to account for interactions between the material and the cultural that emerge within viticultural production, including the role of agronomic expertise and producers' conceptions of agency in the vineyard. I do so through the exploration of *terroir,* using a case study from the world's oldest classified vineyards (first to be ranked in terms of quality) and second oldest legally-protected designation of origin: the Tokaj wine region in northeastern Hungary. The presence of a material, observable *terroir* is highly contentious in the environmental sciences (see for example Gladstones 2011, Maltman 2013), yet it is protected through policy frameworks at national and international scales. The laws that protect *terroir* products refer simultaneously to cultural and techno-scientific explanations in their creation and enforcement (in Tokaj, this trend dates to the 18th century).

Terroir is an exemplary case for exploring the relationship produced between cultural constructs and power relations in the material ecologies of agricultural systems: assemblages of biological organisms, as well as non-living constituents (as in the case of inorganic minerals), including their environment. In particular, this tracing of *terroir* elucidates the role of environmental sciences in *interpreting* value-laden claims on geographies, particularly as ecologies and their products are *material*, while the production of wine relates to value, quality, and other intangible or *immaterial* features—including figurative (and literal sensation of) *taste* (Bourdieu 1984). Whether there are identifiable ecological mechanisms of *terroir* expression, producers and policy-makers are nevertheless making judgments and decisions based on *terroir*-related science, using modern technology and high-resolution data to make socio-cultural and economic claims and influencing concepts of landscape and quality. As ethnographies of *terroir* construction in France have shown, this can drive political privileges to land, quality, and markets (see Demossier 2011, Ulin 1987).

Thus, this thesis seeks neither to confirm nor to "debunk" the *terroir* concept using scientific methodologies; rather, it considers science and technology as social enterprises and asks: What is the role of soil science, its methodologies, and agricultural technology in the socio-ecological creation of *terroir*—the linking of place and taste—in this historic wine region? In other words, rather than taking this connection for granted, the link itself becomes the object of study as a socio-ecological phenomenon. I approach this question using mixed-methods including participatory soil sampling, interviews, and participant observation in Tokaj and Budapest, Hungary.

Beginning with an overview of the geomorphology and soils of the Carpathian Basin in which contemporary Hungary resides, a discussion of soil sampling methodology, data, and results will follow. This section will discuss the quantifiable aspects of two village areas, considered here as sub-regions, within the broader Tokaj region—two areas that many claim constitute separate *terroirs* based on visual and chemical differences in viticultural soils (namely, available nutrients, pH, and contributing parent materials). The second part of the thesis, written as a research article manuscript, will situate these findings in their broader cultural context using an ethnographic, science and technology studies approach, using a concept that emerged during this research and which encapsulates the supposed presence of *terroir* qualities in a wine: *minerality*. This term, which is used with wide-ranging meanings in wine-tasting and production, refers either metaphorically or literally to the sensation of a saline, flint-like texture or taste in a wine.

II. BACKGROUND: A SURVEY OF SOILS AND GEOMORPHOLOGY IN THE CARPATHIAN BASIN (HUNGARY) WITH REFERENCE TO VITICULTURE

The Carpathian Basin (or *Pannonian Basin*, after the preceding Roman province of the same name) and adjacent highlands known somewhat inaccurately as the Transylvanian Plateau[1] constitute much of the contemporary borders of Hungary and a portion of western Romania, Southern Slovakia, Northern Serbia, Western Ukraine, and Eastern Slovenia (FIGURE 1). The basin itself comprises a large flat plain, ringed by mountains with three natural passages to the rest of continental Europe: one leads northwest through Austria, another leads northeast toward contemporary Poland and Ukraine, while a third connects to the Balkan Peninsula through the southern end of the basin (Duffy 2010).

The geophysical boundaries of the Carpathian Basin have often been mirrored by political borders in the region; today, modern Hungary is situated within the larger Carpathian Basin and is comprised of a series of smaller mountain ranges (many volcanic or intermediate-volcanic in origin), rivers and valleys, as well as plains. Much of the Carpathian Basin's modern success as an agriculturally productive region is due to its fertile soils and the temperate climate regime that has

[1] The "plateau" is actually a portion of the Carpathian Mountain range.

marked the region since the close of the Pleistocene. The Carpathian Basin includes "a large compound extensional basin of Neogene and overlying Paleogene basins and interior elements of the greater Alpine fold belt…. Geographically, it lies within the Alpine mountain belts of east-central Europe and is bounded by the Carpathian Mountains to the north and east" (Dolton 1996).

Geothermal spring water, which can be found throughout the Carpathian Basin and neighboring areas, is what perhaps drew some of the first prehistoric settlers (and, indeed, remains economically and culturally significant throughout Hungary). Notably, Late Paleolithic and Upper Neolithic settlers would have found the valleys surrounding the Danube and its tributaries to be the "shortest and easiest highway between North-Western Europe and the ancient centers of civilization in the Aegean and the Ancient East" (Childe 1976:1). However, this corridor is perhaps most distinguished from surrounding regions by its soil, containing tracts of loess, a very fine-grained, porous sediment often carried by Aeolian forces (Bogaard 2004). This region, which connects a portion of Northwest Europe to the Carpathian Basin, has thus been deemed the *loess belt*.

The following section considers geological, climatic, and other primary soil-forming factors leading to the contemporary soilscape of the Carpathian Basin, including two soil types on which this thesis hinges: its famed loess deposits and volcanic soils (often attributed to successful wine production). These are then discussed within the context of the Tokaj wine region. Tokaji[2] soils are considered by both scientists and the lay public/producers to be essential components of the unique wines historically produced in the region, forming the foundations of its legally-protected status beginning in the 18th century. For the purposes of this review, soil taxonomies are primarily discussed with reference to the World Reference Base (WRB) classification system

[2] Tokaji is the adjectival form of Tokaj (i.e., *of* Tokaj)

utilized by the FAO/UN and the European Union, with analogous USDA typologies when available.

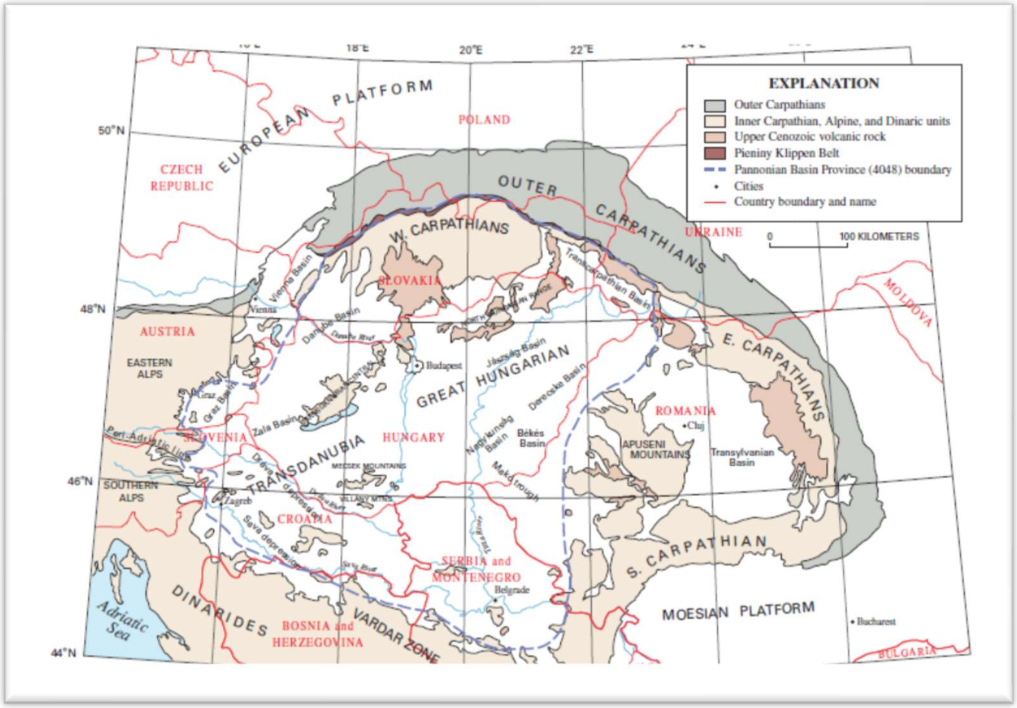

FIGURE 1: Carpathian Basin of Central Europe (Dolton 1996)

a. GEOLOGY OF THE REGION

The Carpathian Basin is a geomorphological subset of the Alipine-Himalayan orogenic belt or *Alpide Belt*, which includes a series of mountain ranges from Spain/Morocco in the west to Central Asia and into the South Pacific in the east. The Alpide Orogeny led to the isolation of the Paratethys Sea from the greater Tethys Ocean during the Rupelian Age (FIGURE 2). The resulting Paratethys was a large, shallow sea formed during the Late Jurassic, isolated during the Oligocene (after about 34 million years ago). Beginning with the Pliocene epoch (from about 5 million years ago), the Paratethys became substantially more shallow, creating a series of interconnected bodies of water that included the brackish Pannonian Sea. Today only the Black Sea, Caspian Sea, and Aral Sea remain of these inland waters, though contemporary soil types in the Carpathian Basin, particularly in the southern plains, are highly evidential of these periods of marine deposition.

The Carpathian Mountain Range encircling the Carpathian Basin consisted of small ocean basins prior to the Alpine orogeny occurring in the Mesozoic. This fold and thrust belt consists of three plates (ALCAPA [Alps, Northern Carpathian, and Pannonia], Tisza, and Dacia) over subducting oceanic crust (Plašienka 2002). Until the Early Jurassic, the Tisza unit belonged to Europe, but became an independent microcontinent, eventually settling into its current place toward the end of the Eocene, rotating about 90 degrees (Less 2011).

The basin itself, including the great plains within, are the result of the drying up of the Pannonian Sea, a shallow body of water that existed during the Miocene and Pliocene epochs, accounting for a three- to four-kilometer depth of deposited marine sediments. Originally part of the larger Paratethys Sea, the Pannonian Sea was insulated by the Miocene uplift of the Carpathian Mountains approximately 10 million years ago and existed, with varying degrees of salinity, for about 9 million years (Schmid et. al 2008).

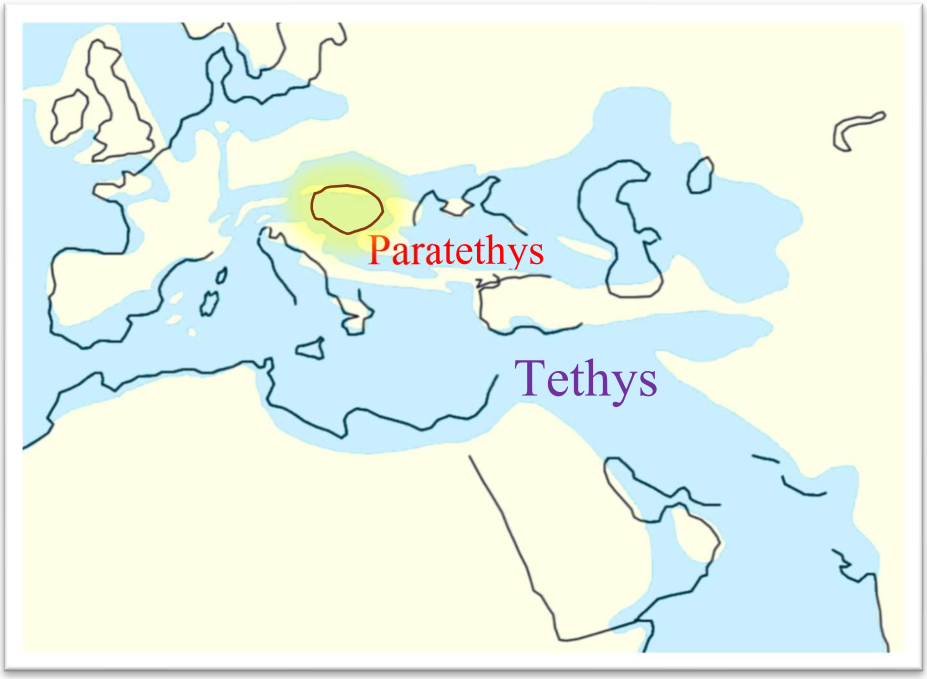

FIGURE 2: The Mediterranean Region during the Rupelian age (33.9-28.4 mya), including the early separation of the Paratethys Sea from the Tethys Ocean by Alpide Orogeny (modified from Woudloper 2008).

b. POPULATING THE CARPATHIAN BASIN

The Carpathian Basin has been deemed a "climatic bottleneck" where today's Mediterranean and temperate Europe meet, creating an enclave in which early European agriculture was fostered and spread (Butzer 1971). This "bottleneck" of warmer climate patterns means that the area is strongly influenced by Atlantic, Mediterranean, and continental forces (Demeny et al. 2013). These areas were surrounded by dense post-Pleistocene forests in the early Holocene that were aided by the sinking of the North Sea coasts due to glacial melt. This resulting influx of salt water into the Baltic depression led, in part, to a warmer, more temperate and moist climate in Northern Europe. Dense pine forests covered Transylvania c. 20,000-10,000 BP

(Dolukhanov 1979). This period has been deemed Atlantic, and "corresponds in Central Europe to the early Neolithic epoch when the walls of the Danubian corridor were at their highest" (Childe 1976:5). The continuous lines of natural resources along the Danube and its tributaries would have drawn nomadic groups into the region from the east, where settlement along the waters provided ideal conditions for farming and trade. During the Holocene, the Carpathian Basin was likely an inhabitable and desirable region, particularly along the prevalent loess belt, although Bogaard notes that – while most early Neolithic sites are found in areas high in loess, this may not have been solely because of the fertility of the soil; other factors drawing people to the region may have included the flat land and its proximity to the conjunctions of river valleys (Bogucki 1988:77).

c. CARPATHIAN BASIN GEOLOGY AT PRESENT: HUNGARY

Present-day Hungary may be divided into a set of seven geophysical subdivisions: The Little Hungarian Plain, the West Hungarian Borderland, the Transdanubian Mountains, Transdanubian hills, the North Hungarian Mountains, and the Great Hungarian Plain (FIGURE 3). The major wine regions of Hungary correlate roughly with these geophysical demarcations.

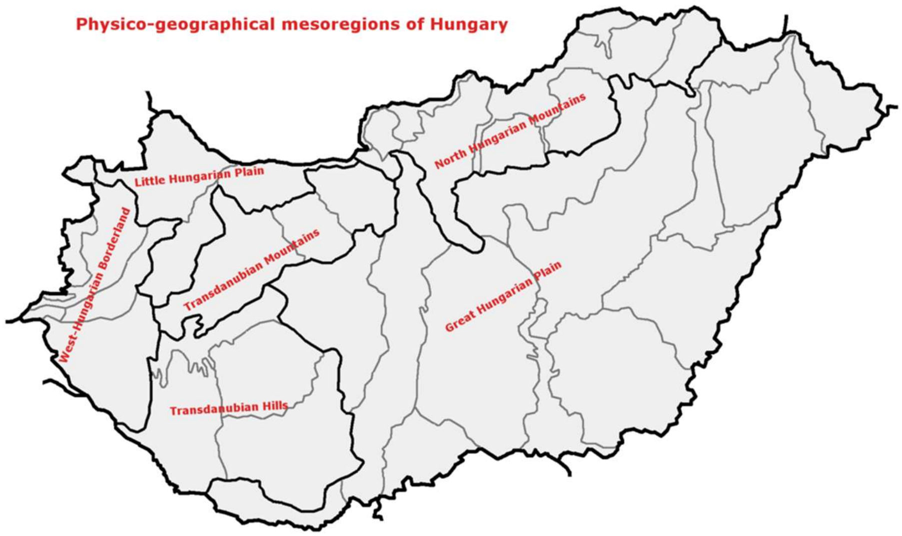

FIGURE 3: Geophysical subdivisions of contemporary Hungary (Fakirbakir 2014)

d. TWO CHARACTERISTIC SOIL TYPES IN HUNGARY

i. VOLCANIC TRANSDANUBIA and "BROWN EARTH"

Formerly islands of the Pannonian Sea, the extinct volcanoes of the Transdanubian region have remained inactive for about 4 million years and appear today as smaller, more rounded hills dense with vegetation and basalt monadnocks[3]. Due to a thin lithosphere (25-28 km) and high geothermal gradient (5-6° Celsius/100 m), Hungary continues to have a wealth of geothermal energy, evidenced by the abundance of thermal waters (Lenkey et. al 2002)—this trait is also referenced by wine producers and professionals in Hungary as a positive trait of their viticultural land.

Aside from the rounded hills and basalt "pipes" that are volcanic relics, the soils of the Transdanubian region of Western Hungary are characterized by dominant *brown forest soil* or

[3] A monadnock is an isolated rock hill that rises abruptly from a sloping hill or plain.

brown earth per the Hungarian soils classification scheme (Aubert and Pinta 1980). Brown earth soils, previously outlined in the 1938 USDA system as simply brown earth, are now typically categorized as cambisols (FAO) or inceptisols (USDA). Cambisols of the Great Plain are young soils defined by a cambic or mollic horizon (the latter overlying subsoil with low base saturation and high organic matter). These soils are developed from parent materials (underlying bedrock) with medium or fine textured colluvium, alluvium, or aeolian deposits (Spaargaren 2008). These soils, being relatively fertile, are prime for cultivation.

ii. AEOLIAN DUST: LOESS IS MORE

Hungary has many rich deposits of loess, primarily Aeolian sediments with some accumulation from alluvial deposition. Sources of loess in Hungary originate from "Aeolian reworking of the floodplain sediments of the Danube and other rivers of Transdanubia and the local Cenozoic sands of the uplifting Transdanubian Central Range and Transdanubian Hilly Region" (Thamó-Bozsó et. al 2014:11). The word comes from the German term for *loose*, which refers to its highly porous composition: typically between 50-55%.

The origin of loess material (FIGURE 4) is revealed by its heavy mineral assemblage and requires four factors for its formation: a dust source, wind energy for transport, an area of accumulation, and duration of time (Frechen 2011). The result can be many meters of transported material; in Hungary many of these loess deposits are found above a reddish, clay horizon (FIGURE 5). These clays and paleosols are reddish (7.5YR7/4) or reddish-brown (5YR 5/6) in color, which is accounted for by the presence of hematite, goethite, maghemite, and 'amorphous' Fe oxides (Kovács et al. 2013).

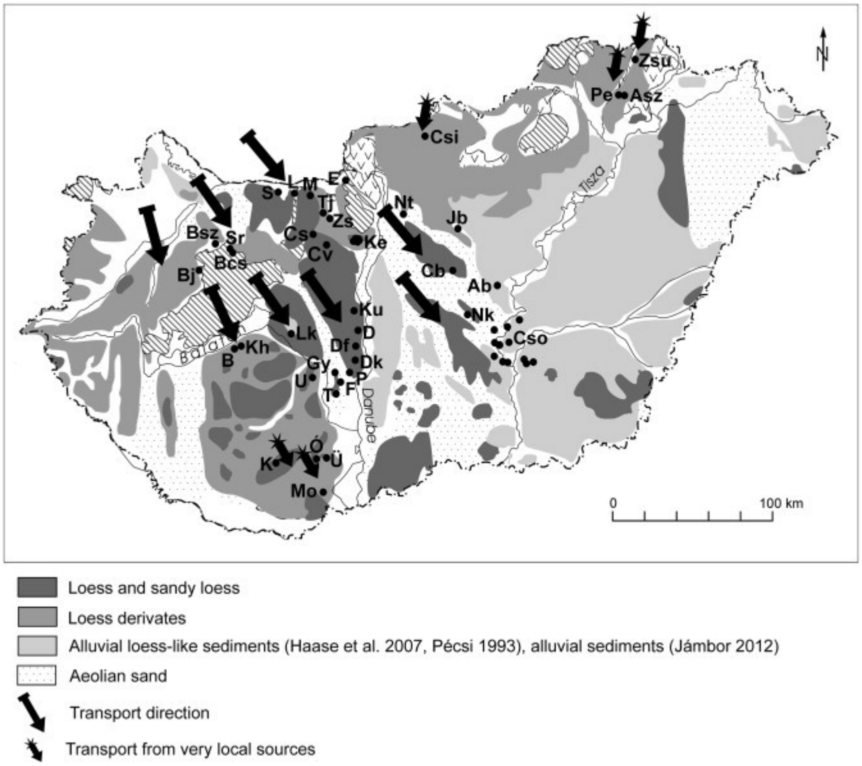

FIGURE 4: Distribution of loess, loess-like sediment, Aeolian sands and paleosol samples with direction of transport indicated (based on mineral composition) (Thamó-Boszó et. al 2014).

FIGURE 5: Red clay underneath Hungarian loess—aeolian dust deposits (vineyard at surface) (Kovács 2008).

1. SOIL PROFILES: TOKAJ REGION

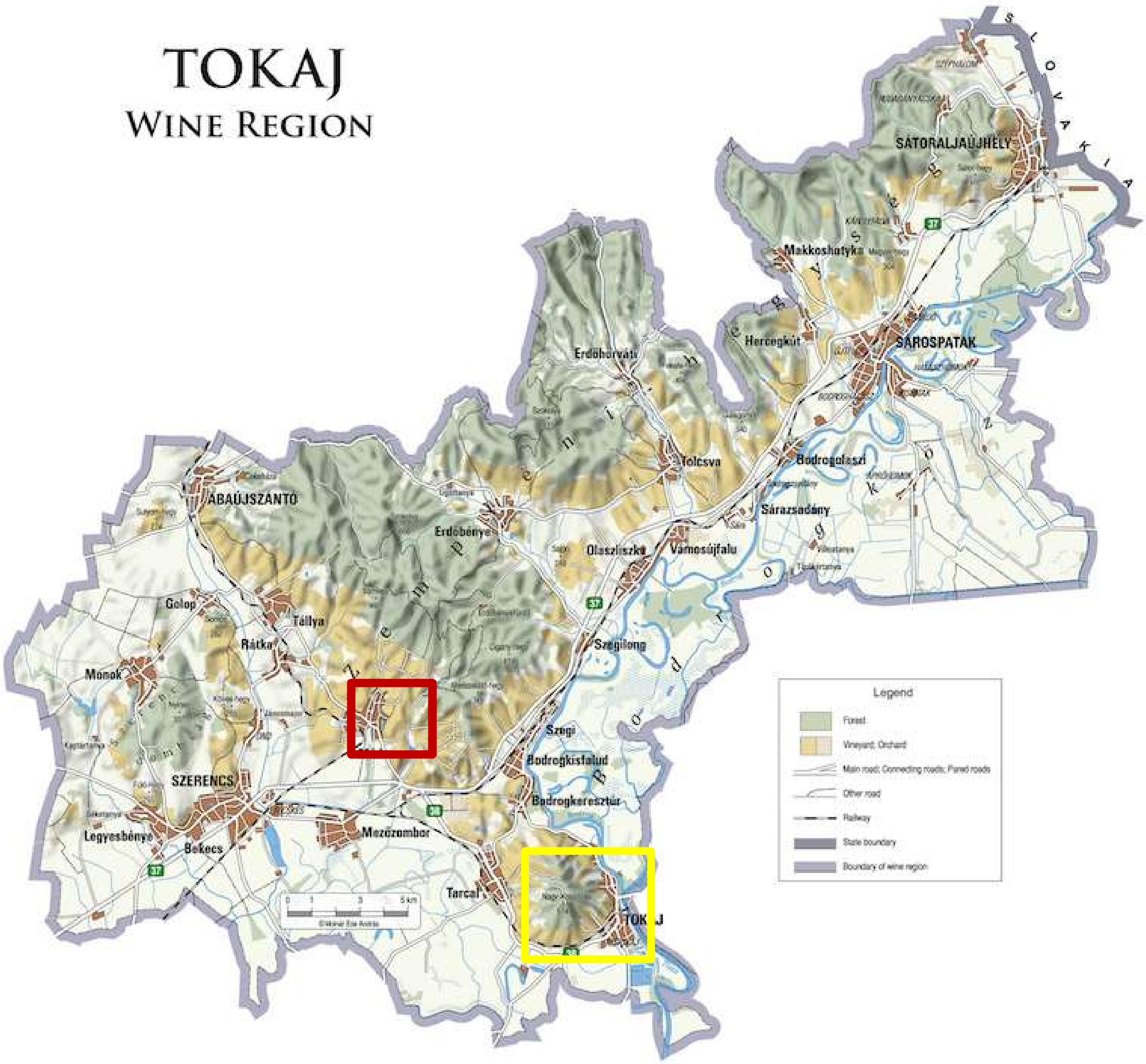

FIGURE 6: Map of the Tokaj region of Hungary with Hamvas area (in red) and Tokaj area (in yellow) (modified from Tokaj Foundation n.d.)

The Tokaj region (FIGURE 6) is perhaps the most famous wine region in Central Europe. As the first classified vineyards in the world (akin to the Cru system of today's France), and the second oldest closed origin of production (the first being Italy's Chianti), it was the also probably first to practice *botrification*, or the utilization of *Noble Rot*: a process that involves an infestation of grapes by the grey fungus *Botrytis cinerea*. Botrification requires high levels of moisture, perhaps provided by the confluence of two major rivers in the region, as well as insulation that is perhaps provided by nearby mountains.

The traditional area of Tokaji wine production, a UNESCO World Heritage site since 2002, is a small plateau about 450 meters above sea level in the Northern Hungarian Mountains. The soils in that area are derived from volcanic parent materials and contain high levels of iron and calcium carbonate, e.g., lime. It is often classified as Braunerde under the former Hungarian system, which is the category that includes brown forest soil. The FAO analogue would be *Phaeozems*, which are (thapto-)cambic or skeletic (having 40% or more gravel or other course fragments). This correlates roughly to udolls or mollisols in the contemporary USDA system.

The region owes its existence to Neogene and Pleistocene volcanic formations. Pedologic studies of the Tokaji region were most likely the first European survey of volcanic soils, and it is worth noting that, in publications that followed (and oftentimes today), "the term volcanic soils was used as a synonym for vineyard soils" (Fehér et. al 2011:131). However, it differs from other volcanic areas of Hungary, such as the basalt-dominated Badacsony wine region, in that the Tokaji area is dotted with brown forest soils, or cambisols/inceptisols with Andesite substrates (Fehér et. al 2011), making for a highly heterogenous landscape.

FIGURE 7: Soil profile at Tokaji, presented to wine tourists (Jörgensen 2012).

The dryness and so-called "minerality" of its native wines is often attributed to underlying soils (pyroxene andesite) and previous intermediate volcanism. The table below (TABLE 1) represents a characteristic soil profile of the Tokaj village area. It was recorded by Fehér et al. 2011 in Tokaj at an altitude of 480 meters on a slope with westward exposure, a gradient of 10%, mesic soil temperature regime, and udic soil moisture regime:

TABLE 1: Representative soil profile at Tokaj (Fehér et al. 2011).

Horizon	**Depth (cm)**	**Color**	**Texture**	**Structure**	**Boundary**	**Special Features**
Ao	+2-0	Moder				
A1	0-12	10YR 2/1	Loam	Angular blocky	Diffuse	Worm galleries
A2	12-45	10YR 3/1	Fine silt loam	Subangular blocky	Wavy	Worm galleries
2B + D	45-60	10YR 4/3	Loam	Angular/subangular blocky	Abrupt	Worm galleries, stone line

Humus type was described as acid mull, a "well developed fine granular porous structure with many noticeable macro-pores" (Fehér et. al 2011:137). The acid mull humus type may be indicative of intense weathering, which produces active iron hydroxides, as well as biological activity.

e. SOILS AND GEOMORPHOLOGY IN THE CARPATHIAN BASIN: CONCLUSIONS

The geologic history of the Carpathian Basin has created a heterogeneous landscape in which modern-day Hungary defines its borders. This has led to seven distinct geological subdivisions, which are mirrored to some extent by traditional wine regions. While no extensive comparison of geological boundaries and wine region demarcations has been undertaken, it would be interesting to look further into these relationships. Unfortunately, soil maps of Hungary remain relatively low-resolution as recently as 2011 (FIGURE 8).

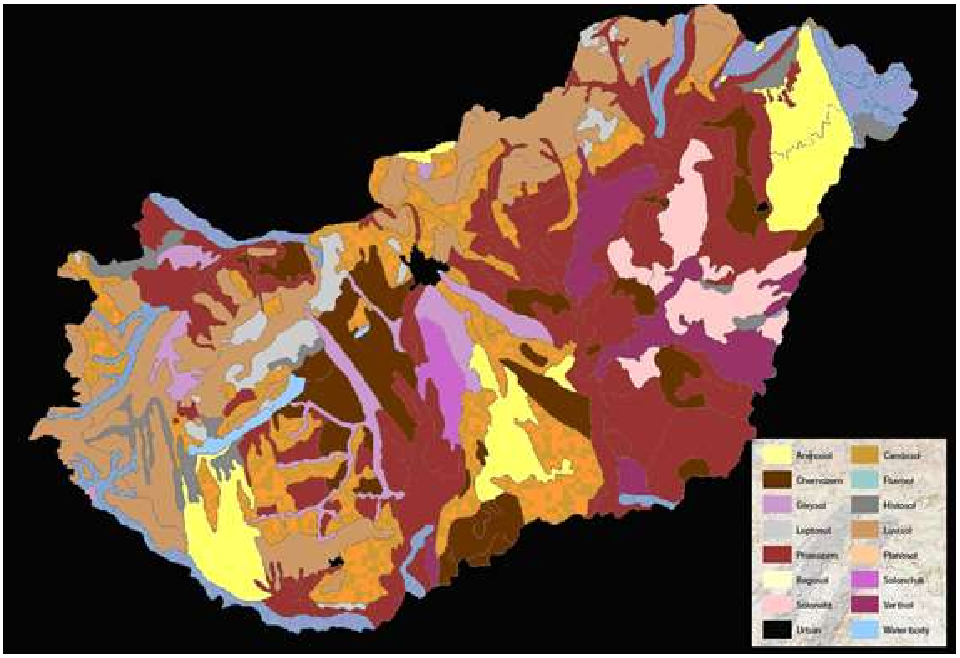

FIGURE 8: Hungarian soils according to the FAO/UN World Reference Base (European Commission 2011).

There is ongoing dissonance between soil classification systems; while the FAO/UN World Reference Base has replaced local or state-level soil taxonomies in the EU where official matters are concerned, there are still processes of translation as witnessed in the literature. These translations link WRB types, not only to former Hungarian state soil classifications, but also to folk taxonomies (common names for brown forest soils, etc.) and USDA systems (both antiquated and current versions). While many of these categories find analogous counterparts in the other systems, there are often overlapping types with slightly different diagnostic features (Fehér et al. 2011). Soil scientists recognize this disharmony, suggesting that the short-term solution is to correlate existing data within a common scheme (Láng et al. 2013).

Hungarian soil types, often descriptive, include names that are often long and self-defining (and, therefore, can be very specific and unmistakable). Unlike most modern classifications, the traditional Hungarian scheme "does not use diagnostic horizons and has practically no artificial terms" (Krasilnikov et al. 2009:170). However, due to the "fuzzy" nature of the boundaries of soil classes, the limits of each category do not align well with World Reference Base for Soil Resources (WRB) types, although the modern Hungarian classification system aims to correspond closely with the WRB taxonomy.

TABLE 2: Structure of the Hungarian soil taxonomic system (Krasilnikov et al. 2009:172)

Level	*Taxon name*	*Taxon characteristics*	*Borders between classes*	*Diagnostics*	*Terminology*
0	Soils	Kingdom			
1	Main type	Collective	Fuzzy	Landscape-morphological	Traditional
2	Type	Generic	Fuzzy	Chemico-morphological	Traditional
3	Subtype	Specific	Fuzzy	Chemico-morphological	Traditional
4	Variety	Varietal	Mostly formal	Chemico-morphological	Traditional

The traditional Hungarian taxonomic system used since the 1950s (TABLE 2) features four levels and is organized by supposed predominant pedogenetic processes. To present one example, the Hungarian Main Type Brown Forest Soils is presented in TABLE 3 alongside possible WRB correlations, and WRB correlations are matched with their nearest USDA equivalents.

TABLE 3: Categorizing seven Hungarian soil types (from a single main type) within the WRB taxonomy, which is then correlated with its nearest USDA match (Hungarian/WRB classification matching from Krasilnikov et al. 2009:172). N.B., all of these are only partial matches.

Hungarian Soil Name	Level	Possible Correlations Across Taxonomies			
Brown forest soils (barna erdőtalajok): a main type containing seven types (below)	**Main type**	***Closest WRB Type for Hungarian Soil Types, Left***			
		Cambisols	**Umbrisols**	**Luvisols**	**Chernozems**
Acidic, non-podsolic brown forest soils (savanyú nem podzolos barna erdőtalajok)	Type	✓ (Dystric)			
Podzolic brown forest soils (podzolos barna erdőtalajok)	Type			✓ (Albic)	
Brown forest soils with clay illuviation (agyagbemosódásos barna erdőtalajok)	Type			✓	
Stagnating brown forest soils (pangóvizes barna erdőtalajok)	Type	✓ (Stagnic)		✓ (Stagnic)	
Ramann's brown earth (Ramann barnaföldek)	Type	✓	✓		
Banded brown forest soils (kovárványos barna erdőtalajok)	Type			✓ (Lamellic)	
Chernozem brown forest soils (csernozjom barna erdőtalajok)	Type				✓ (Luvic)
Closest USDA Matches for WRB Types, Above		**~Inseptisol**		**~Alfosol**	**Mollisols-Ustolls**

The soils of the Tokaj region are unique in the Carpathian Basic for their high levels of heterogeneity, a quality that many Tokaji producers foreground and that is (at least discursively) linked to *complexity* in wines. Because of this heterogeneity, the literature on Hungarian geology and soils would benefit from greater consideration of agricultural/viticultural soils in-situ and to a higher degree of resolution. While the geology of the region has created a variety of unique habitats for endemic and non-native species, little is known about the connection between the soils and the overlying biota. This clarity may come from a better understanding of soil types within competing classification systems, as well as further comparative studies between vineyards and wine regions.

CHAPTER 2

SOIL TESTING RESULTS AND DISCUSSION

I. CONTEXT: DISSERTATION RESEARCH COMPONENT

This project and lab analysis fulfills the requirements to complete a master's thesis in the Department of Crop and Soil Sciences at the University of Georgia. This project also intersects with a larger dissertation project underway in partial fulfillment of the PhD in Anthropology (Ecological and Environmental focus). The experience gained during the Crop and Soil Sciences coursework and fieldwork is not only applicable to the dissertation topic but allows me the privileged position of being literate in crop and soil sciences as a social researcher. Thus, data collected for both projects—outlined below—are in dialogue and may be cross-referenced, although different analytical and theoretical frameworks will be deployed. For this thesis, a specifically *social studies of science* approach will be used, focusing on a subset of topics that will only be briefly touched upon (though referenced through this paper) in the upcoming dissertation (December 2018).

As such, the remainder of this thesis is divided into two sections: first, methodology, soil test results, analyses, and discussions are be presented (Chapter Two); second, elaboration and interpretation of the soils and ethnographic data is presented, relegated to Chapter Three of this thesis, which is written in a journal manuscript format.

II. METHODOLOGY

The purpose of this study is twofold: first, to complete a comparative soils study of two sub regions within the Tokaj-Hegyálja wine region of Hungary, utilizing best practices and standard methodologies for agri-viticultural soil tests (Chapter Two); second, to pair these data with ethnographic data collected in-situ to account for the minerality concept in viticulture through the lens of science and technology studies (Chapter Three). Together, these chapters address the central research question: What is the role of soil science, its methodologies, and agricultural technology in the socio-ecological creation of *terroir*—the linking of place and taste—in this historic wine region? Together, these two chapters represent two paradigms essential to the research question: an agricultural sciences approach and a social studies of science lens, respectively—with Chapter Three contextualizing the data presented in Chapter Two. Both of these aims are in fulfilment of the requirements for the Masters of Science in Crop and Soil Sciences.

The interdisciplinary nature of the research question guided a mixed-methods framework, which merged environmental sampling and ethnographic methodology (participatory soil sampling/vineyard tours and walking interviews). Thus, this project foregrounded participant observation and interview (participatory environmental sampling, guided vineyard tours, and walking interviews) completed in summer 2015. It was also informed by subsequent participant-observation in wine courses and laboratory settings in Budapest, Hungary and the Tokaj wine region 2016-2017.

a. DATA COLLECTION

i. Participatory environmental sampling

This research foregrounded a participatory approach, which pairs well with the research question and to the science and technology studies framework of analysis: rather than predetermining which vineyards to sample, or the boundaries of the sampling sites, my aim was to *participate* in and *observe* those very decisions as they typically occur at these sites. Thus, I explained the project to producers and asked them, as guides, to take the lead. This allowed me to understand the rationale of producers (the decision-makers) rather than import a, perhaps more systematic, sampling regime. This approach is similar to that of *citizen science* (Kimury and Kinchy 2016) in that it is *participatory*; however, while many participatory methods engage the "lay public" in the implementation of wider scientific studies (often as instruments of observation—counting birds, for example), my aim was to involve producers with all of their local knowledge in the design of the research (soil survey) itself. This provided insights that would have been unafforded by traditional approaches, and prioritized data pertaining to the research question (i.e., the creation of *terroir*-related knowledge).

Thus, producers were asked to give tours of their vineyards (or rows within vineyards, as most parcels are shared between multiple owners), presenting areas in which they perceived differences to exist (additionally, dividing vineyards into zones based strictly on varietal type was not a feasible consideration due to the heterogenous layout of grapevines within vineyards). These delineations occurred without prompt in many cases; for example, one producer was very enthusiastic about having five types of loess in his single, small vineyard and chose to present it specifically for this reason. His assessment of his vineyard's diversity of soil types was based on the visually different colors and textures of the loess soils. In cases such as these, each "zone" was sampled as defined by the producer (in this case, by color variation).

Once the areas to be tested were chosen, they were divided per Agricultural and Environmental Services Laboratory at the University of Georgia (AESL) instructions, based on vegetation and soil characteristics. This involved walking in a "zig-zag" pattern to take approximately eight to ten samples from each zone, which ranged from approximately 120 m^2 to

850 m^2. For the soil sampling round, eight tours of as many vineyards[4] were completed (five in Tokaj village with three producers; three in Hamvas[5] village with two producers) (FIGURES 9 and 10). Within the five Tokaj vineyards, a total of twenty-five composite samples were collected (representing twenty-five sub-zones, the boundaries of which were determined by producers). Within the three Hamvas vineyards, a total of eight composite samples were collected (representing another eight producer-identified sub-zones).

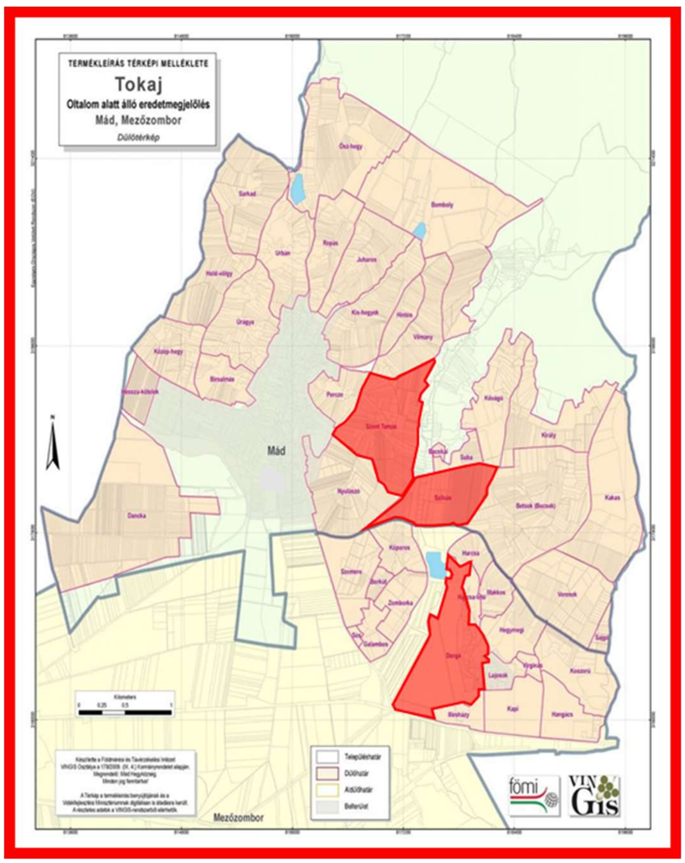

FIGURE 9: Hamvas area detail, with dűlő-*s (referred to here as vineyards) outlined.*

Toured/sampled vineyards highlighted in red.

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[4] Referred to in later sections as *dűlő*-s, although the terms are not exactly synonymous.

[5] Hamvas village is a pseudonym.

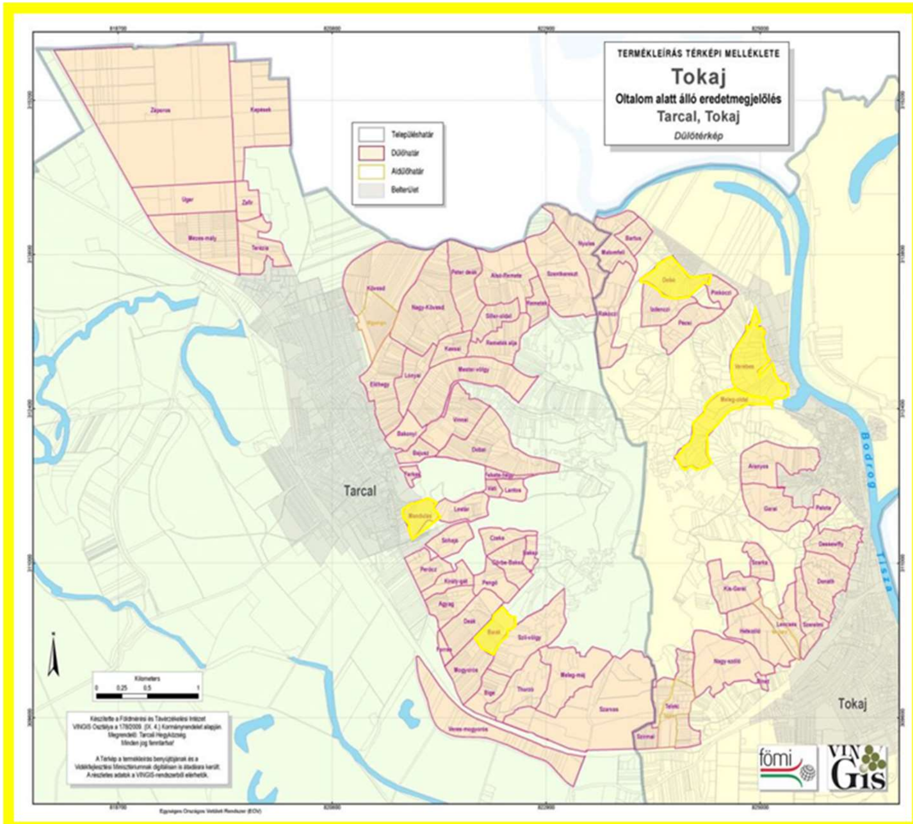

FIGURE 10: Tokaj village area detail, with dűlő-*s (referred to here as vineyards) outlined. Toured/sampled vineyards highlighted in yellow.*

Soil collection involved stratified random sampling of the entire vineyard alongside the current grower/owner or, in one Tokaj vineyard, a village consultant with experience growing in those particular locations. Composite samples included the collection of 8-10 samples to a depth of 10 cm using a 20-cm, 2.5-cm diameter auger and represented areas between 0.15 and 1 hectare. Samples were consolidated in a paper bag or bucket, mixed, then re-sampled and poured into an AESL paper bag, where the composite was labeled using a region-, site-, depth-, and zone-specific identifier. Waypoints were taken at each site. The sampling of zones within vineyards allowed for the preservation of any variation *within* vineyards for later comparison (these zone-level samples may then be averaged together for a "whole vineyard" sample for comparisons *between* vineyards.) In addition to these 0-10-cm samples, a second strata was sampled at 10-20 cm using a trowel or shovel (to create a larger hole in order to view any striations or anomalies in the soil profile) and a 20-cm auger with a 2.5-cm diameter. Visual and chemical differences between the 0-10-cm and 10-20-cm soil depths were not great, suggesting relative uniformity in the solum (in most vineyards sampled, the solum was exceptionally thick and lacked clear horizons) (e.g. FIGURES 16-18).

ii. Ethnographic and historic data collection

The environmental sampling outlined above included informant-led walking tours of vineyards during sampling with producers/consultant and included a series of open-ended interview questions pertaining to the management and history of each tract. These interactions were audio-recorded and photographed. Marketing materials were also collected from both Tokaj and Hamvas villages as part of the summer 2015 study, including publications by the Hamvas Roundtable referenced in Chapter Three. Notes (jottings) were written in the field, while detailed fieldnotes were expounded upon following each tour/interview/soil sampling event.

As part of the larger doctoral dissertation project, a series of wine festivals, events, harvest activities, lectures, and tasting courses were attended and participated-in, audio-recorded, and photographed when possible. This included twenty-two additional producer and wine professional interviews, thirteen of which were guided tastings and four of which involved vineyard tours. This also included a total of thirty-four tasting events (lectures, guided tastings, festivals, etc.). Historic publications pertaining to Tokaj wines (1730-1989), as well as contemporary marketing materials (post-1989), were also collected for the dissertation project. Detailed observational/field notes were written for each interview and event. These data, collected 2016-2017, provide context for the case study presented in this thesis and are referenced in Chapter Three, although to a much lesser extent.

b. ANALYSIS

i. Environmental samples

Soils were allowed to dry in open paper sample bags for 48 hours, during which time a portion of each sample was taken, saturated with water, and matched to a Munsell soil chart in order to classify each sample bag based on color. Bagged soil samples were then packed and sealed in an airtight cooler, then wrapped again for security per USDA regulations. They were shipped from a central post office in Budapest, Hungary, to the laboratory of Dr. Aaron Thompson at UGA. Upon receipt, samples were transferred to the Agricultural and Environmental Services Laboratory (AESL) at The University of Georgia by personal vehicle. At this point, the samples were handled in the way that the many thousands of samples are handled at the AESL, where the author participated in soil analysis and related environmental testing activities.

At the AESL, boxes were opened, and samples were counted and compared to submission forms included. Samples were ordered as per the submission forms and arranged in a shallow cardboard box at a rate of 36 samples in each box. Boxes were then given ID numbers to trace the set number, dates, and tests requested. Tops were cut from sample bags to allow for more rapid drying. The soils were then placed in a walk-in oven, where they were exposed to 43°C for 12 h or until dry.

Once dry, soils were ground using a stainless-steel grinder and pressed through a 2-mm screen (US Screen Series #10.) Grinding and sieving soils prior to testing is essential, as unground/unscreened samples are often full of small stones, plant parts, and other nonuniformities. A ground sample makes for a more homogenous sample, which is important given the small volume of soil used in Mehlich I analysis (Mehlich 1953).

For analysis of available nutrients, vials received 20-mL Mehlich 1 solution (0.05 N HCl in 0.025 N H_2SO_4) and 5g of soil. The vials were then shaken in the solution on a shaker for five minutes. This mixture was then filtered using Whatman #1 paper into flasks to separate the soil particles from the liquid. The remaining extract was placed into vials and placed around a carousel in a specific order designated by the AESL and also includes check, duplicate, and blanks. The extracts were then loaded onto an Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES) for elemental analysis.

To test for pH, 20-mL scoops of each sample were placed into small paper (Dixie) cups, including checks and duplicates. The set of cups was loaded into a reagent dispenser where each cup was filled with 20 mL of 0.01 Molar $CaCl_2$. A robotic pH meter was used to generate the results. pH derived using this dilute salt solution method is found to be an average of 0.6 units lower than when measured in a 1:1 soil:water solution, thus the values reported here are in the equivalent water pH (pH in calcium chloride + 0.6). Soluble salinity was measured as electrical conductivity in a soil slurry (Rhoades 1996). Organic matter was determined using dried, ground soils and the loss on ignition (LOI) method, measuring weight loss between 375° and 800° Centigrade using a muffle furnace.

ii. Ethnographic and historic data analysis

All audio collected was transcribed verbatim in its original language; all Hungarian dialogue was then translated into English for analysis. Field notes were taken primarily in English except for verbatim phrases or quotes, which were later translated into English. Translations were cross-checked with one of two native Hungarian speakers to account for nuance (particularly in the often-synesthetic vocabulary of wine tasting). Interview and presentation transcriptions were transcribed verbatim in the original language, and Hungarian dialogue was translated into English for analysis. Video/photo materials and marketing materials in both Hungarian and English were summarized in English for analysis, where quotes were translated from Hungarian to English as needed for citation.

All of these transcripts and materials, including full field notes, were imported into the Atlas.ti software package for qualitative analysis through two rounds of coding: initial In Vivo "values" coding (to account for perspectives, worldviews, and broad themes), followed by pattern coding (to categorize respondents' answers and find commonalities, discrepancies, etc.) (Saldana 2015:48). In analyzing the walking interview data collected during 2015 and comparing these themes to further interview rounds, it became apparent that the key themes of producers who participated in soil sampling (including the primacy of soils in narratives of quality) were echoed and reinforced by other regional winemakers. Thus, this paper foregrounds the 2015 case study, which is complemented by further interview rounds in the region and the context provided by historic documents.

III. RESULTS AND DISCUSSION: SOIL TESTS

a. ANALYSIS: COMPARATIVE SOIL HEALTH

Statistical analyses of quantitative soil test results (considered in two groups: Tokaj and Hamvas soils) were compared using the Mann-Whitney *U* test for unpaired groups. This estimates the probability that a randomly chosen soil from the Tokaj group (TK, n=25) has a different value (for a given nutrient, pH, etc.) as a randomly chosen soil from the Hamvas group (HV, n=8), reported in its accompanying *p*-value. Plant-available nutrients (Zn, P, K, Ca, Mg, Mn) are reported in mg kg-1. Readings of pH ($CaCl_2$), soluble salinity (mmhos/cm) and organic matter were also compared[6] and similarly analyzed for differences. Raw data appears as APPENDIX 1. In available nutrients tested, all showed significantly different distributions between Tokaj and Hamvas sites ($p<.01$). Of the three additional analyses considered, pH between Tokaj and Hamvas groups significantly ($p<.01$), while soluble salinity and percentage organic matter did not (p>.01) (TABLE 4).

TABLE 4: Mann-Whitney U tests of soil testing results

Nutrient	**C (mg kg-1)**	**K (mg kg-1)**	**Mg (mg kg-1)**	**Mn (mg kg-1)**	**P (mg kg-1)**	**Zn (mg kg-1)**	**pH ($CaCl_2$)**	**SS (mmhos /cm)**	**OM (%)**
Median: Tokaj sites	5854	48	248	9	9	0.1	8.4	0.18	2.0
Median: Hamvas sites	1029.5	140	100	45	101	12.9	6.3	0.09	1.9
Mann-Whitney U	11	25	13	23	34	14	3	44.5	98.5
***p*-value, two-tailed**	0.000	0.001	0.000	0.001	0.006	0.000	0.000	0.021	0.968

b. RESULTS

1. Comparisons between Tokaj and Hamvas

Through visualizing the data described above, the differences between Tokaj and Hamvas area sites can be seen at a glance. Available nutrients (FIGURES 11 and 12) between Tokaj and Hamvas vineyards differ significantly (Ca is shown separately from K, Mg, Mn, P, and Zn due to the difference in scale):

[6] Lime buffer capacity was not analyzed, as the majority of Tokaj samples, as well as one Hamvas sample, did not yield results due to their high Calcium content.

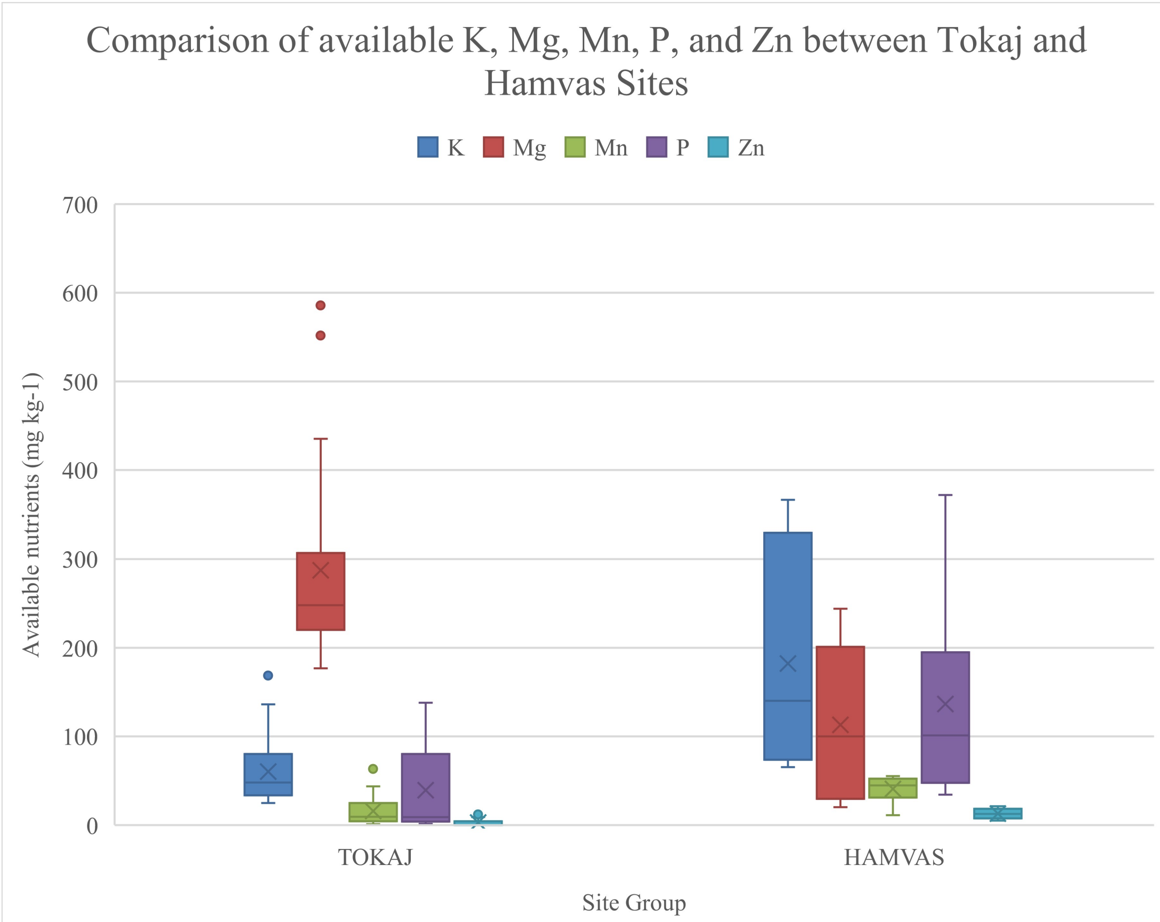

FIGURE 11: Comparison of available K, Mg, Mn, P, and Zn between Tokaj and Hamvas sites

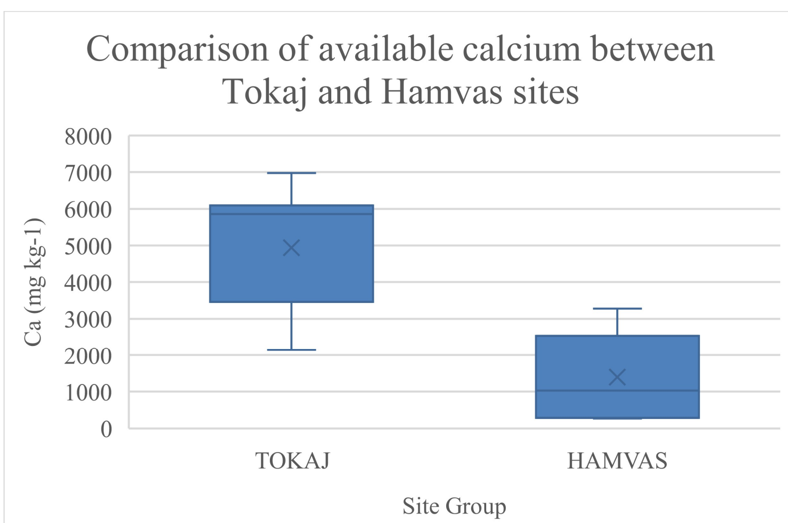

FIGURE 12: Comparison of available calcium between Tokaj and Hamvas sites

Looking further at pH, soluble salinity, and organic matter, the differences (significant for pH, while not significant for soluble salinity and organic matter) can be viewed (FIGURES 13-15).

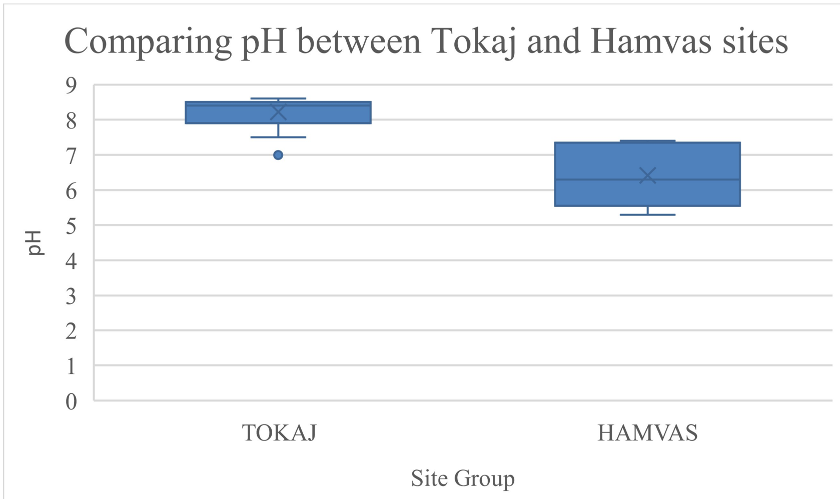

FIGURE 13: Comparing pH between Tokaj and Hamvas sites

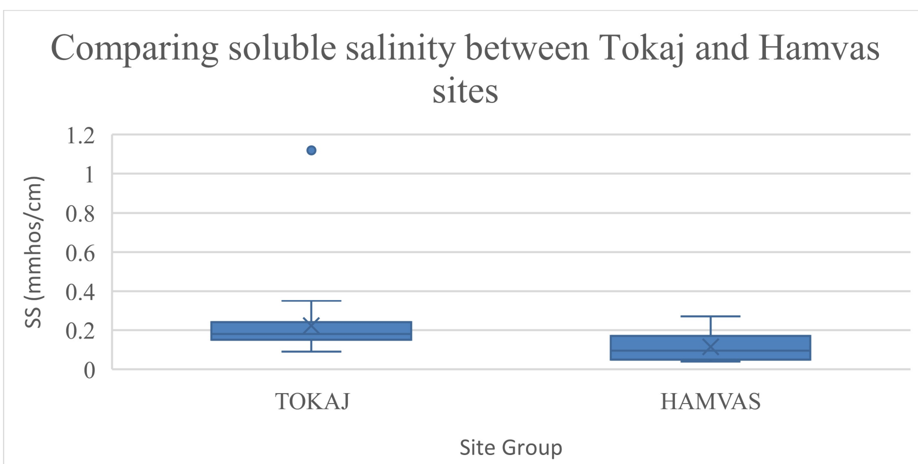

FIGURE 14: Comparing soluble salinity between Tokaj and Hamvas sites

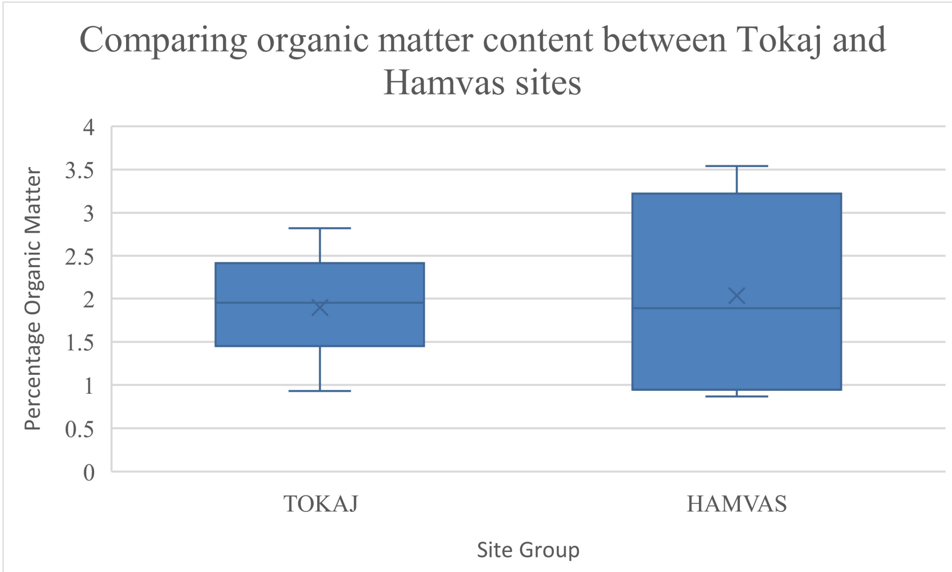

FIGURE 15: Comparing organic matter content between Tokaj and Hamvas sites

2. Comparisons within vineyard sites

The heterogeneity of soils within vineyards was referenced by producers as a positive feature of their *terroir*. In vineyards where sub-sections were tested, variability became apparent. Perhaps the most illustrative example from Tokaji vineyards is *DŰLŐ A*, the site described as having "five types of loess" by Dáni, winemaker and consultant (FIGURES 16-18, following pages).

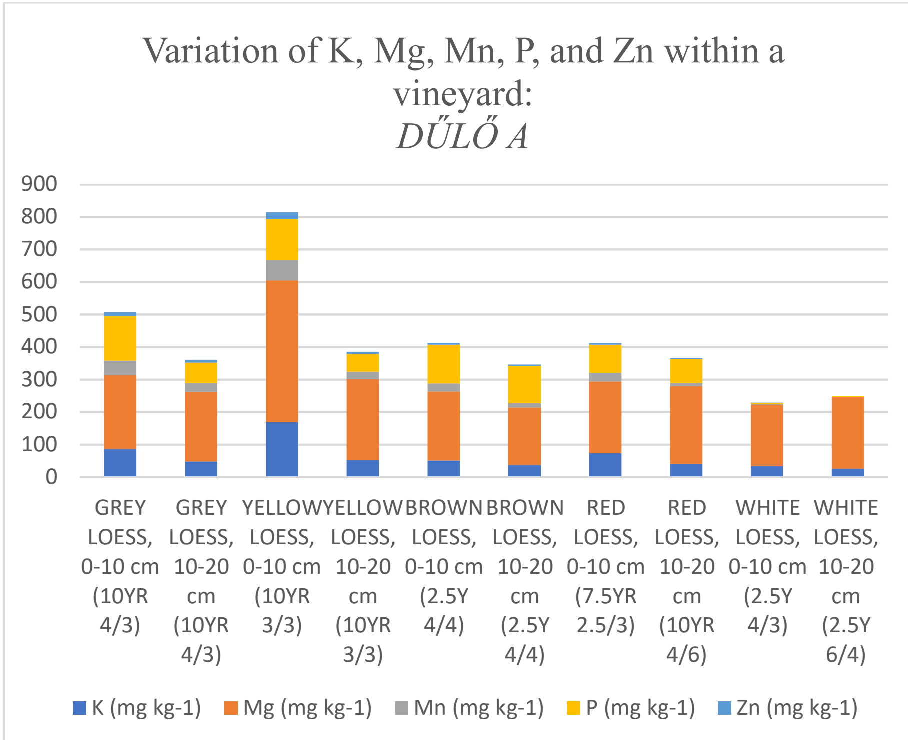

FIGURE 16: Variation of K, Mg, Mn, P, and Zn within a vineyard: DŰLŐ A, "5 types of loess"

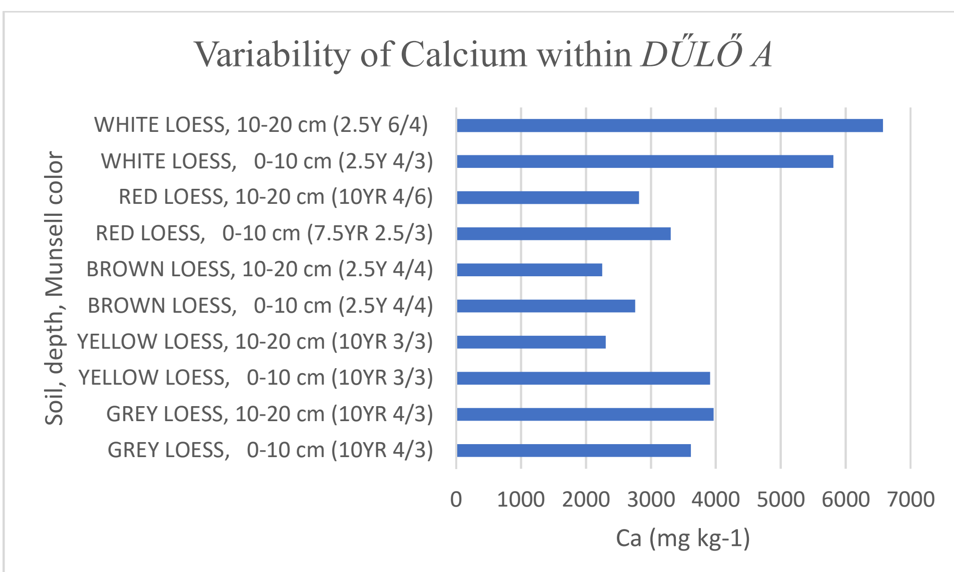

FIGURE 17: Variability of Calcium within DŰLŐ A*, "5 types of loess"*

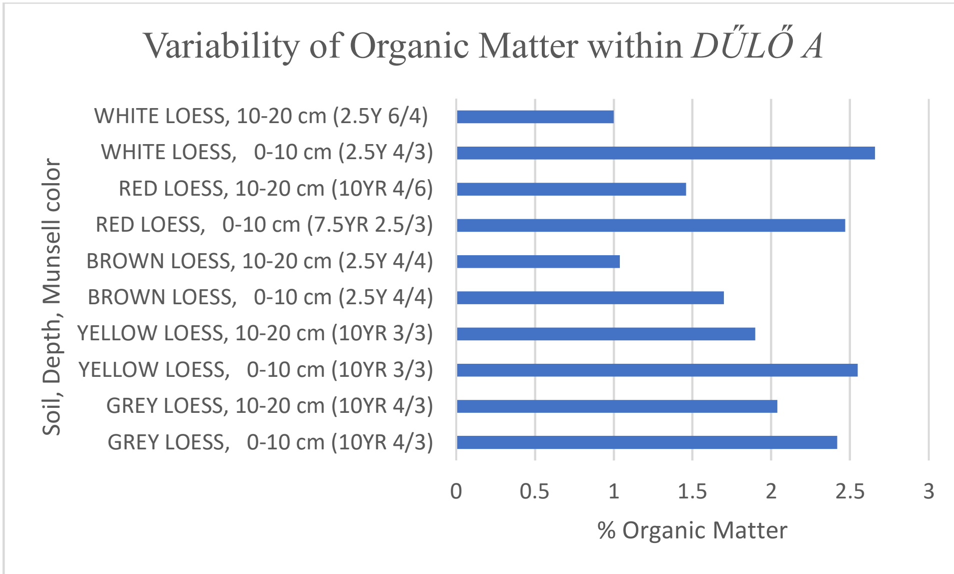

FIGURE 18: Variability of Organic Matter within DŰLŐ A*, "5 types of loess"*

As illustrated in FIGURES 16-18, available nutrients and organic matter varied greatly within the same site (and same soil type, loess). These differences were highlighted through the informant-led selection, which was based on visually distinctive portions of the site (different color top soils). The soil names used in the figures are the informant's, while a Munsell match is used to specify the color observed (with the wet sample).

Available calcium present in different sections varies greatly, for example, in "white loess", values are nearly three times higher than the "brown" or "yellow" sections (probably due to the amount of calcium inclusions present, correlating to the white color of the soil). This same white section was also comparatively lacking in phosphorous. Interestingly, organic matter ranged 1-2.7% across the site, with this entire range represented in the two "white loess" strata tested (white loess 0-10 cm and 10-20 cm). This trend held constant through the other loess sections, where shallow soils held (unsurprisingly) a higher percentage of organic matter than their lower counterparts.

Variation of available nutrients in a Hamvasi[7] vineyard can be seen in *DŰLŐ H*, which is a terraced hillside (FIGURES 19 and 20). Here, the producer suggested sampling two adjacent terraces, assuming that differences may exist between the two due to the slope of the hillside/run-off.

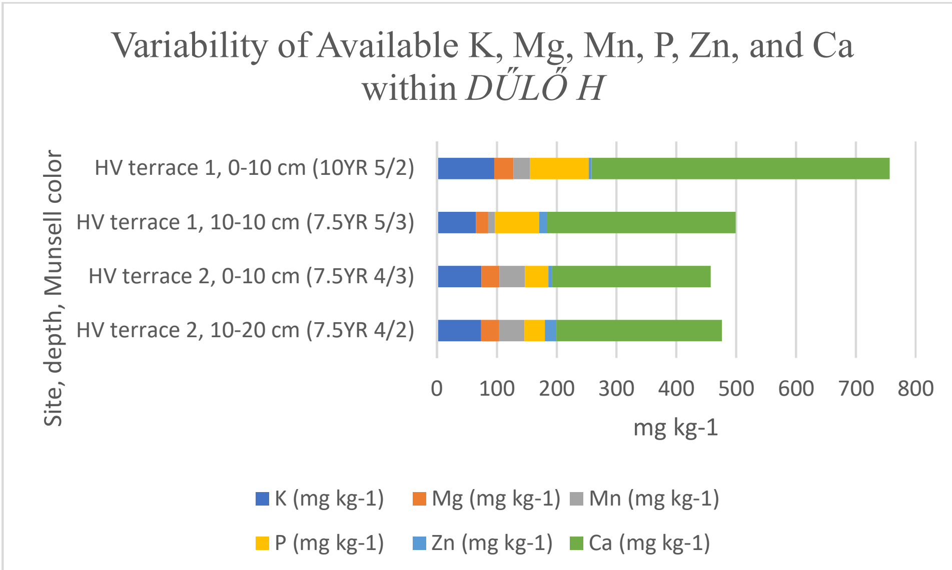

FIGURE 19: Variability of Available K, Mg, Mn, P, Zn, and Ca within DŰLŐ H *(Hamvas terraces)*

The variability in this Hamvas vineyard site, while perhaps not as great as the Tokaj example above, provides another account of hetergeneity within sites (not just between them). One other notable trend in the Hamvasi site is the organic matter content (FIGURE 20, following page).

[7] Hamvasi is the adjectival form of Hamvas (i.e., *of* Hamvas)

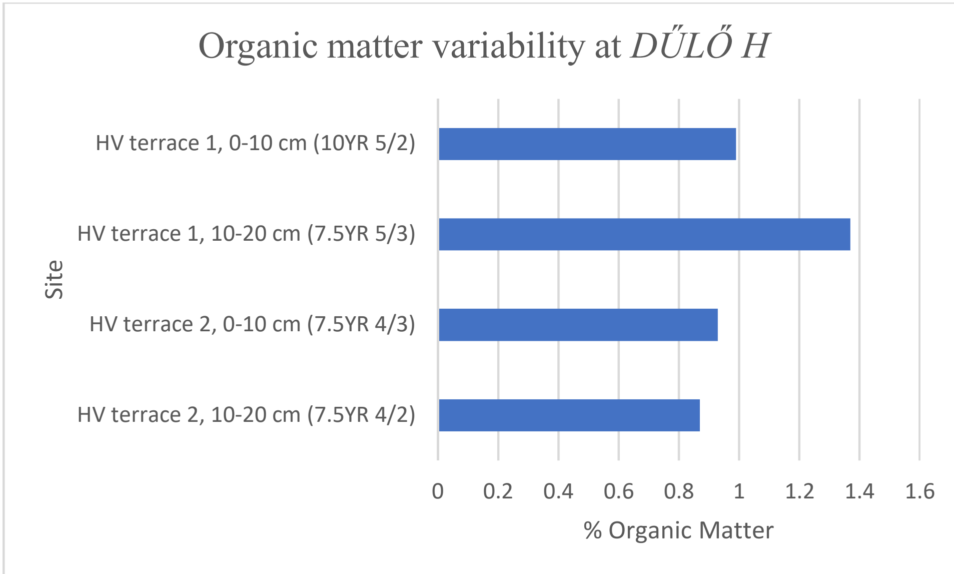

FIGURE 20: Organic Matter Variability, DŰLŐ H

Interestingly, the highest percentage organic matter was found in the lower depth sampled of terrace 1 (10-20 cm), the only example of higher organic matter in a lower stratum. This correlates with activity at the terraces; the vines here were newly planted (<1 year in age), which would have led to a recent disturbance of the top soil.

c. DISCUSSION

It is important to situate these findings within the literature on viticultural soil health and recommendations. Macronutrients needed by *Vitis vinifera* (the Eurasian wine grape) include nitrogen, phosphorus, potassium, calcium, magnesium, and chlorine, with micronutrients including iron, zinc, manganese, copper, boron, molybdenum, and chlorine. Of these, boron and nitrogen can cause toxicity in high amounts, and too much of the later can also cause canopy management problems (overabundant foliage) (see White 2003, Wilson 1998, Coombes and Dry 2006). Contemporary conventional wisdom suggests that ideal viticultural soils are well-drained, of moderate depth, and with moderate fertility, leading to higher quality fruit. Thus, modern soil management practices recommended by extension agents and laboratory services adjust recommendations accordingly. The University of Kentucky Extension Service recommends the following table as ideal for *V. vinifera*:

	University of Kentucky Extension*	Ohio State University Extension**	Iowa State University Horticulture**	Natural Resource, Agriculture, and Engineering Service***
Soil pH	5.5 - 6.8	5.5 - 6.5	6.0 - 6.5	N/A
Organic matter	2 - 3%	2 - 3%	2 - 3%	3 -5%
Phosphorus (mg kg-1)	20 - 25	20 - 50	> 30	20 - 50
Potassium	125 - 150	> 150	> 150	75 - 100
Magnesium	100 - 125	100 - 125	100 - 125	100 - 250
Zinc	4 - 5	4 - 5	3 - 4	2

*FIGURE 21: Recommended nutrient ranges for V. vinifera (*Kurtural et al. 2008, **Adapted from Rosen 2013, ***Wolf 2008). University figures represent Mehlich-3 analysis results.*

Generally, recommendations for pH values typically between 6.0 and 7.0 (5.5 for some indigenous varietals) in order to promote maximum availability of nutrients. This is because nutrients are only plant-available (usable by the grapevine) under certain soil conditions, pH being one of the driving factors (FIGURE 22).

In acidic soils with a pH less than 5.5, phosphorous can become unavailable to the plant because there are high amounts of free aluminum and iron (the former can also impede cell division at the root tip, preventing growth) (Walter-Peterson 2013). Phosphorous depletion occurs when aluminum and iron precipitate phosphorous out of the soil solution. It is interesting, then, to note the exceptionally high levels of phosphorous seen in the vineyards of Hamvas (which averaged 136.2 mg kg-1), given the low pH of its soils. Because terrestrial legacies of phosphorous accumulation are documented to be long-lasting, particularly in moist conditions (Deiss et al. 2017), it is possible that these readings reflect an earlier attempt at fertilizing a nutrient-poor landscape in an effort toward mass production.

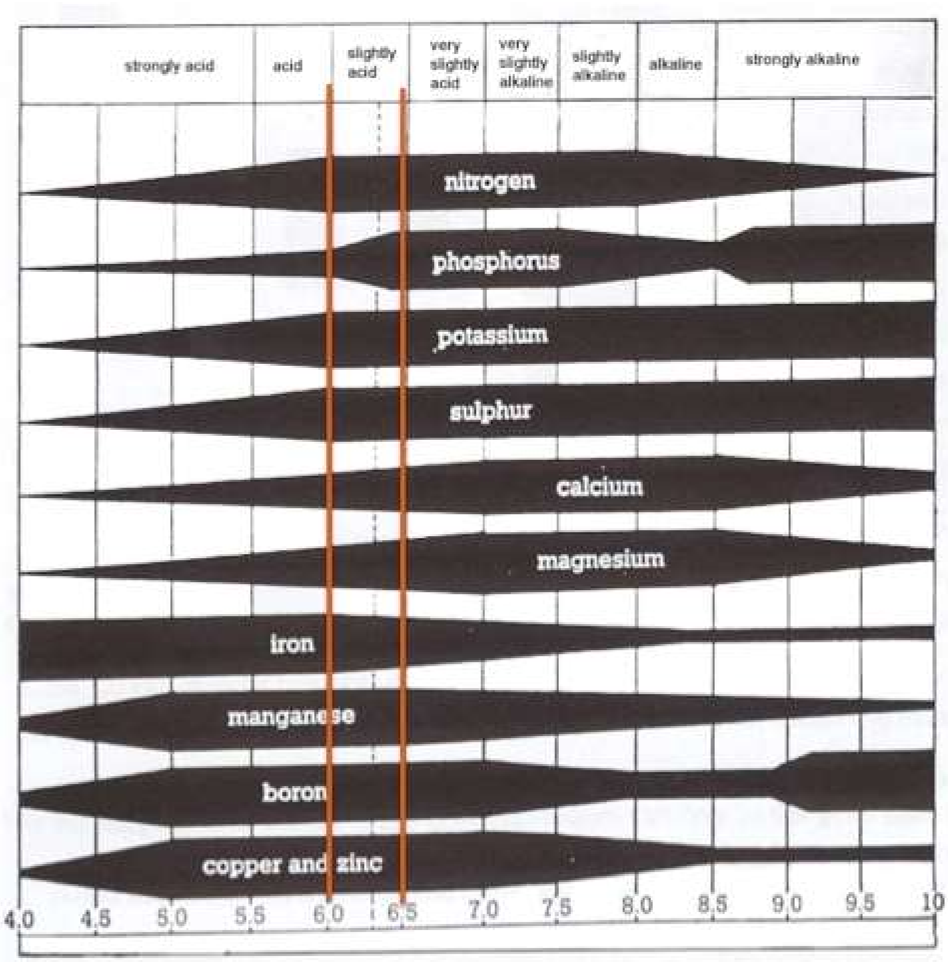

FIGURE 22: Effect of pH on plant-available soil nutrients (the red margins outline an ideal range) (Bates and Gee n.d.).

The results from Tokaji soil analyses are in-line with expected results from loess soils, complete with high levels of calcium, pale array of colors (ranging from near-white to pale yellows with almost green properties [APPENDIX 2]), and the very small particle sizes perhaps most characteristic of the soil type. As wind-blown silt, loess soils retain heat and water (ideal for cooler, sunny regions) and are thought to contribute to so-called smooth, or round-tasting wines with low levels of acidity. In this context, the limestone (seen in Tokaj sites, sometimes as inclusions within loess horizons, and certainly related to the overabundance of calcium in Tokaji soils) may contribute to quality grapevines through a higher pH, where cation exchange is increased with high levels of base saturation (Bates and Wolf 2008); however, if the aim of producers is to provide only *limited* nutrients, this may be viewed as detrimental.

*FIGURE 23: Winemaker and regional consultant Dáni showing a calcium inclusion, or "loess baba" (literally, loess baby) in one of his vineyards (*DŰLŐ A*).*

Low pH soils, such as those seen in Hamvas's vineyards—derived from volcanic parent material, Hydrogen ions may displace the ions of primary macronutrients. This can be a concern where the pH is lower than 6.0, as seen at site #MD-03, where the average pH across the vineyard was only 5.7, over one hundred times more acidic than the average of Tokaji vineyards (8.2). Again, the objective of the winemaker (influenced by market trends and demands), will categorize this pH as either contributing to quality (through protecting the vine from an abundance of nutrients) or detrimental (too limiting in production quantity).

One thread of debate in viticultural soil management is the percentage and role of organic matter. In the results presented here, a range of .9-3.5% for Hamvasi and .9-2.8% for Tokaji soils, both averaging around 2%. Between Tokaj and Hamvas areas, organic matter does not appear to differ significantly, nor was it referenced by producers during interviews.

Although the Mehlich analysis used here is a relatively contemporary methodology, we can refer to older Tokaji texts for alternate methods of analysis of soil composition (rather than plant-available nutrients), including readings of organic matter. Interestingly, organic matter averages found in the analyses of Tokaj soils above are drastically different from the 1867 readings from the Tokaj-Hegyáija Album (FIGURE 24). The Album lists the Tokaj area (under "loess" vineyards, in line V.) as having 6.103% organic matter, while a local Hamvas area site (Várhegy, under "clay" vineyards, line IV.) is listed as having 0.703% organic matter.

D.

TABLEAU DES PARTIES CONSTITUANTES

DES SOLS DE TOKAY-HEGYALJA.

	Séparément											Parties in-solubles	Parties volatiles					Total
	Soluble dans l'acide chlorhydrique										Total		séparément		Total	il yen a		
	KO	NaO	CaO	MgO	Al^2O^3	Fe^2O^3	PO^5	CO^2	SiO^3HO	SiO^3			Humus	mat. organ.		-N	-C	
α. Argile plastique.																		
I. Zombor, Kir ály.	0,181	0,304	0,671	0,179	10,395	8,076	0,251	—	1,850	3,879	25,911	64,889	4,600	4,600	9,200	0,285	2,76	99,901
II. Liszka, Meszes.	0,176	0,617	0,709	0,149	8,706	9,473	0,031	—	1,000	9,526	30 439	64,561	2,220	2,780	5,000	0,067	1,332	99,948
III. Zsadány, Elő-hegy.	0,446	0,911	0,408	0,138	14,578	7,886	0,080	—	2,366	7,678	34,541	55,059	5 013	5 387	10,400	0,229	3,006	99,950
IV. Ujhely, Várhegy	0,568	0,698	0,115	—	6,365	4,742	0,027	—	1,216	9,093	22,824	74,171	2,297	0,703	3,000	0,034	1,378	99,995
β. Loëss.																		
V. Tarczal, Szarvas.	0,254	0,443	2,050	0,257	10,373	7,457	0,216	1,604	1,978	2,343	26,975	62,304	4,497	6,103	10,600	0,341	2,69	99,879
γ. Ponce.																		
VI. Erdő-Bénye, Pe-res.	0,273	0,643	0,372	—	8,257	5,384	0,080	—	1,186	1,516	17,812	[illegible]1,588	3,750	6,850	10,600	0,045	2,250	99,898
VII. Ujhely, Oremus.	0,279	0,584	0,365	—	5,702	5,018	0,033	—	1,311	6,800	21,112	72,888	—	—	7,000	—	—	99 980
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
	Singly											Not soluble	Volatile parts					Sum
	soluble in muriatic acid										Sum		singly		Sum	therein		
	KO	NaO	CaO	MgO	Al^2O^3	Fe^2O^3	PO^5	CO^2	SiO^3HO	SiO^3			Humus	organic matter		-N	-C	

TABLE SHOWING THE CHEMICAL COMPOSITION

OF THE SOLS OF THE TOKAY-HEGYALJA.

FIGURE 24: 1867 chemical analysis of Tokaj region soils, with V. being most representative of Tokaj and IV. being most representative of Hamvas. Figures are shown in percentages, which total to roughly 100 (rightmost column) (Szabó and Török 1867:147).

While not specifically the same sites as were tested in this study, these historic data indicate that, even in 1867, there may have been significant variation between these two areas in terms of organic matter; furthermore, Tokaj sites may have lost average percentage organic matter (the same table shows all other regional sites as having exceptionally high organic matter compared to today's readings or recommendations, ranging from 2.780% to 6.850%). This is especially of interest considering today's push for dry, mineral white wines (over sweet wines), which require less nitrogen/organic matter in order to promote smaller, "starved" bunches (as will be discussed in Chapter Three). It may be that the soil, in its depletion over time and over decades of monocultural use, has depleted alongside these changing consumer preferences.

1. Tokaj and Hamvas as distinctive soilscapes

The soils analysis presents Tokaji and Hamvasi vineyards as containing highly heterogenous soils both within and between sites. Nevertheless, by comparing the means found at each site, there are statistically significant differences between the two regions, when all sampled vineyards are grouped together, with regard available nutrients. Of these nutrients, only Tokaji soils exceeded Hamvasi soils in available calcium, which is not surprising, given the igneous origin of Hamvas surface soils and the loess-covered slopes of Tokaji vineyards. This would suggest, where colloquial, soil-based definitions are in use (i.e., those who refer to available nutrients as the elusive *minerality* characteristic in wine), Hamvasi vineyards constitute a distinctive *terroir*.

As will be discussed at further length in Chapter Three of this thesis, the distinction of Hamvasi vineyards rests predominantly on its claim to volcanic top soils. Because *V. vinifera* retrieves nutrients no further than depths of .5-.6m (Keller 2010), a visually distinctive solum may reflect a truly different vine root habitat. The resulting soils in Hamvas, which are generated from igneous parent material (high in free quartz) are acidic, weathered soils that are lacking in available nutrients and have a significantly lower pH than those of Tokaji vineyards sampled (Hamvas averaging 6.14, while Tokaj averages 8.22). This distinction is also heavily referenced by producers and is discussed in Chapter Three.

Also referenced by producers, and mirrored here in the soils data, is the concept of vineyard soil heterogeneity—typically, as a prized or sought-after feature of production sites. As presented in the two examples above (from *DŰLŐ A* and *DŰLŐ H*), variation within vineyards is high. We are able to account for this variation thanks to the participant-led nature of the soil survey. While soil types did not necessarily change within these zones, the visual cues followed by producers did lead to (sometimes drastically) different zones of production. Although in both cases producers reported adding no fertilizers, any amendments or recommendations for these soils would benefit from this higher-resolution account of variability, particularly as these sites may have been over-fertilized in the past (judging from high rates of P found in Hamvas sites).

Of course, these results do not point to a definitive marker or causal explanation of *terroir*; rather, it illustrates the material differences between (and within) two villages within one small wine region, quantifiable in terms of available nutrients and pH. Considering the flexibility of current PDO regulations in the region (*anything* sweet, dry, or sparkling made with the six approved varietals and grown within the borders of the region may be labeled and sold as *Tokaji*), and the lack of standardization in methodology across the region, the results of the soil analyses present a landscape that is also *materially* fragmented, without the homogenous growing conditions that are often assumed for a given PDO (especially in winegrowing, where geographically-anchored labels presuppose a certain amount of regional homogeneity).

As will be discussed in Chapter Three, it is the political fragmentation of the region that makes environmental homogeneity the most probable uniting force for some winemakers in the region. This is leading a new generation of rogue producers in Hamvas to pursue their own PDO and quality labeling scheme based on the distinction of Hamvas soils (specifically, their *solum*—Tokaji soils also share volcanic bedrock, though this is buried underneath many meters of loess). In this context, scientific expertise and assessments such as the soil testing presented above become politically-charged tools: the new language of argument in a centuries-old vie for distinction. Thus, in this thesis, the soils data collected in 2015 will be contextualized by ethnographic data from 2015 and—to a lesser degree—data collected in subsequent interview rounds 2016-2017, which involved fieldwork undertaken for the PhD in Anthropology.

CHAPTER 3

MAKING MINERALITY MATTER: A SCIENCE AND TECHNOLOGY STUDIES (STS) APPROACH TO THE MINERALITY CONCEPT[8]

> *"The vine and its wine are a great mystery. Only the vine reveals to us what is the real taste of the earth."*
>
> Sidonie-Gabrielle Colette

I. INTRODUCTION

Terroir, broadly conceived as "the taste of place" (Trubek 2008), may be understood as the unique assemblage of climate, soil, and culture that define a particular geographic area, supposedly essentialized in the food products of that region. *Terroir* has been described as a simultaneously biophysical and social mechanism that endows exclusive qualities to these foods. Recently, an assortment of policy frameworks use *terroir* to secure and label the origins of national and regional foods: a dialogic phenomenon co-produced between the social and material realms. These policies, broadly known internationally Geographical Indications (GIs) include the more specific Protected Designation of Origin (PDO) of the European Union (EU); in all their international and state- or local-level iterations, GIs regulate foods and crops as intellectual and biological property, geographically fixed (e.g. Vidalia onions, Roquefort cheese, Champagne), and protected internationally through The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS). Limited empirical data exist to support a biophysical link between place, plant, and taste quality; despite this, through food labels of origin, these intangible aspects of a particular place-based food are standardized, giving the elusive *terroir* a legal expression denoting quality (Josling

[8] Brawner, A. J., A. Thompson, M. Cabrera, and J. J. Thompson, to be submitted to *Social Studies of Science*

2006). Forming the basis of protectionist policies that regulate food origins, it lies at the nexus of human and ecological systems – yet, it has never been theorized as a socio-ecological system in academic literature.

This chapter uses a science and technology studies approach to examine tensions between the material and the cultural that emerge in the production of wines, explored using a grounded case study from the world's second oldest closed designation of origin: the Tokaj wine region in northeastern Hungary. The *terroir* notion is perhaps most pervasive in winemaking, where it ranges from a mythological to legal to techno-scientific concept. The materiality of *terroir* is highly contentious in the environmental sciences (see for example Gladstones 2011, Maltman 2013), yet reified and protected through policy frameworks at national and international scales. The laws that protect *terroir* products refer simultaneously to cultural and techno-scientific explanations in their creation and enforcement (in Tokaj, this trend dates to the 18th century).

Rather than engage with polarizing debates surrounding the [im]materiality of *terroir*, I consider the *terroir* phenomenon as exemplary of relationship between culture, power, and ideologies within material agro-ecological systems. This is because ecologies and their products are material, while cultural constructs and ideological motivations are behind the decisions that drive the shaping of agro-ecological systems. In this case, producers (and consumers) are making judgments based on *terroir*-related science, using scientific methods to make socio-cultural and economic claims.

Thus, this chapter seeks to understand the co-produced, social-scientific explanations that permeate the world of wine using a case study in Hungarian wine country. Following local initiatives to brand a reinvigorated, historic wine region post-1989, which hinge on distinction through volcanic origins and *minerality*, it asks: What is the role of soil science, and its methodologies in the socio-ecological creation of *terroir*? This question is answered using a mixed methods approach involving participatory soil sampling and long-term, immersive ethnographic methodology in the oldest classified vineyards (and second oldest legally protected *terroir* in the world), Tokaj. I propose that, despite the surprisingly scant literature on *terroir* in Science and Technology Studies (STS), it is an exemplar of the co-production of the social and scientific realms (Jasanoff 2004), blurring the lines between culture and nature, science and politics, and re-framing soil science as a techno-social enterprise.

As this chapter will illustrate, the scientific world of winemaking is not always about identifying *terroir*, as one would document a fingerprint or sequence DNA—where data are collected and interpreted—but rather serves as its own signifier and agent of translation. Interpreting and mobilizing soil science expertise means evidence like *minerality* becomes a sort of currency, underpinning narratives of quality.

II. SCIENCE, SOCIETY, AND PLACE-BASED FOODS

a. Science and Technology in Society

Interdisciplinary scholarship in science and technology studies has elucidated not only the ways in which "science and technology permeate the culture and politics of modernity" (Jasanoff 2004:2), but also how modes of scientific inquiry are moderated by social forces, considering science and technology as socially embedded pursuits. A key theme in this literature includes technology and scientific knowledges as socially shaped. Techno-scientific phenomena are "combined inextricably with social/political/ economic/psychological phenomena, so 'technology' includes a spectrum of artifacts, techniques, organizations, and systems" (Jasanoff 2004:2). This view of science and technology as socially situated seeks to add nuance to our understanding of the creation of facts, disparities in knowledge, how theories are framed, and the ways in which results are interpreted.

This perspective has had a critical role in understanding and solving many contemporary crises, particularly in the global food system. To take one example, the social conditions of labor and consumption have influenced food production, creating new selective pressures that have led to novel, ideal habitats for harmful pathogens (Stuart 2011); in another, advancements in logistics and transportation have altered the morphology of key species like the honey bee (Kosek 2014). Similar studies of environmental science highlight the labeling of "endangered" and "manageable" species as rooted in identity politics (Stokland 2015), or question the presentation of natural disasters as, indeed, *natural* (Fortun and Frickel n.d.). As Jasanoff highlights, rational choice models and neoclassical economics have provided only schematic accounts in efforts to drive research and development toward higher levels of knowledge production because "the dominant discourses of economics, sociology, and political science lack vocabularies to make sense of the untidy, uneven processes through which the production of science and technology becomes entangled with social norms and hierarchies" (2004:2).

The project of social studies of science is ultimately in exposing the invisible structures within which science is pursued: how political and social contexts shape scientific paradigms. Thus, a social analysis of science and technology is not necessarily about dismantling the authority of "objective" or positivistic disciplines alone, but may have at its core the very practical aim of contextualizing scientific epistemologies as inherently *human* endeavors, facilitated by human drives, aims, and inspirations: social constructs and the quirks of human imagination are often borne-out in techno-scientific actions (Jasanoff suggests the Y2K phenomenon as one example [Jasanoff 2004]).

Certainly, consideration of science and technology as a socially-driven enterprise is an especially fruitful analytical lens in the agricultural sciences, where nature and humanity are perhaps most inextricably entangled. The story of agricultural innovation, from the domestication events of the Neolithic revolution to present-day globalized mechanization and rationalization, is one of ultimately human and non-human cooperation. In this chapter, I take as key to this 'STS' paradigm the variety of human and non-human constituents within ecosystems in understanding *terroir* as a collaboration that bridges the human and non-human worlds. My analysis of *terroir*—emerging through the case study below—hinges on respondents' casting of non-human (indeed, often non-living) elements into roles of influence. Using a human/non-human network of actors and actants as a metaphor, I suggest the *terroir* concept is an illustrative example of another concept with Latourian origins, *co-production* (1993).

b. The Idiom of Co-Production

Muñoz-Erickson et al. (2017) identify two primary strands within contemporary co-production literature, with the term being used in two ways. First is the co-production of knowledge (as described by Van Kerkhoff and Lebel 2006:202): a "prescriptive and instrumental form as it invokes an agenda where relationships can and should be deliberatively designed and managed for improving the scientific basis of decision-making at the project and program scale". This line of inquiry, used increasingly in policy reform and sustainability science lends itself to application, seeking to "make knowledge systems more useful" (203). This approach moves past traditional framings of knowledge production and seeks to model decision-making processes beyond the unidirectional "science → policy" interface (Muñoz-Erickson et al. 2017).

The second strain of co-production—with which this chapter primarily engages—follows Sheila Jasanoff's analysis of the production and use of knowledge as socially/culturally/politically embedded. In her reading, scientific knowledge emerges at the confluence of four cultural domains: cognitive, social, normative, and material. This lens is also applicable in policy and sustainability spheres, where the four cultural domains span policy cultures (bureaucratic, civic, economic, scientific), each of which interact with each other—often with opposing logics—and continuously shape social order (Jasanoff and Wynne 1998) (see FIGURE 25).

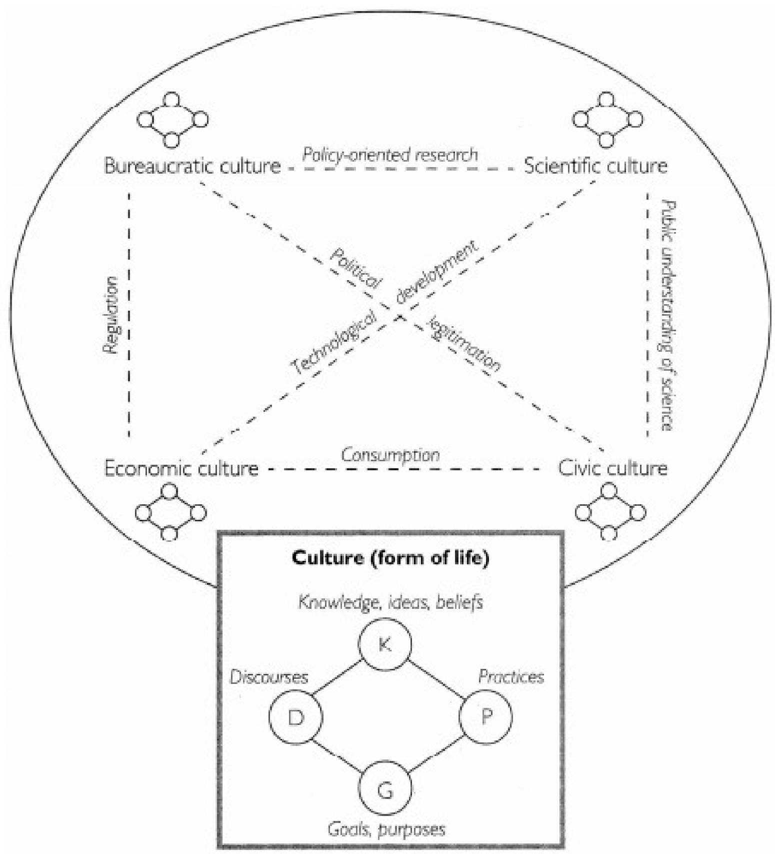

FIGURE 25: Model of co-production of knowledge/society, from Jasanoff and Wynne 1998.

This concept of co-production stems from Latour's presentation of the nature-culture divide as an artificial (more specifically, *western*) dichotomy (Latour 1993). Following this model, co-production argues primarily that there is explanatory power in considering "natural and social orders as being produced together" (Jasanoff 2004:2); in other words, "co-production is shorthand for the proposition that the ways in which we know and represent the world (both nature and society) are inseparable from the ways in which we choose to live in it" (Jasanoff 2004:2): society cannot function without knowledge, and knowledge cannot be gained or exist outside of societal supports. Science and—perhaps especially—technology can thus be viewed as embedded in every facet of the social world, including identities, norms, conventions and institutions. In turn, these norms and identities shape the way science is done: how questions are framed, what tools are used to answer them, and how results are mobilized.

As Jasanoff is quick to point out, the concept of co-production is not a tried-and-true *theory*, per-se, complete with predictive power, but serves primarily as an *idiom*—an analytical framework that accounts for complex phenomena through a symmetrical understanding of both: 1) the rendering of the socio-cultural dimensions of knowledge production, and 2) the "material correlates of social formations" (Jasanoff 2004:3), in other words, how formations typically relegated to the immaterial realm are made manifest. The object, then, is to shed light on the invisible connections that enable co-production to occur, in order that both "'natural' objects, such as the cloned sheep Dolly or the Ozone hole, and 'social' objects, such as experts or governments, can be seen as linked together in actor networks" (22) where linkages between actors cross this imaginary nature/culture binary.

To turn to the case of agriculture, co-production might underscore the embeddedness of cultural factors (e.g. *what counts as 'food'*) driving research questions in agricultural sciences (e.g., *optimizing production of that food*), while at the same time illustrating how ideologies and politics (e.g. *dietary trends, subsidies*) materialize in agro-ecologies (e.g. *soil management practices, varietals planted*). In short, the lens applied here is not "post-fact", but rather seeks to uncover the context of "fact-making"—not to undermine the production of knowledge, but to *situate* it (Haraway 1986). It is from this viewpoint that I seek to understand the branding of place (*terroir*-based labeling schemes) as the confluence of two co-produced forces: environmental science (specifically, soil science) and socio-political inclinations. The outcome is a value-laden approach to soil science, where scientific knowledge and expertise become a sort of currency on a market increasingly interested in distinction and locality: in grounded food systems. I argue that *terroir* and *terroir* products may be viewed through the lens of co-production, where place (material agro-ecologies) and tastes (immaterial experiences) are co-produced.

c. Branding places: The origin of PDOs

Terroir in earlier times was a negative feature of wines that, due to shortcomings in quality, could not be sold outside of a given region; eventually, the term came to be associated with agricultural products of particular origins (Martin 2002). It became trendy in the 1990s, though this fashion has roots in early 20th-century Burgundy and Bordeaux. Here, powerful landowners and producer unions defined notions of quality, taste, and geographical origins to promote existing power structures; this was accomplished through the purporting of both unique geographic qualities and wine-making methods. This included, for example, exclusive use of preferred materials, such as wood with the lightest weight, which (under the guise of tradition) also secured advantages through lower shipping costs. These "invented traditions" of French wine regions were eventually underpinned by French Appellation de l'Origine Contrôlée (AOC) legislation and now by international legislation, including those of the European Union (EU), ostensibly designed to promote the planting of traditional plant varietals and encourage heritage methodologies (often thought to be more sustainable).

Whereas *terroir*-based claims to superiority were once based primarily on "trump cards" of uniquely superb geological qualities (Josling 2006), since the 1990s, *terroir* discourse in France has shifted toward a narrative that encompasses culture, history, and identity, capitalizing more directly on nostalgia and pre-existing reputation as part of a national project of Patrimonialisation: the "effort to trace, record, and commemorate with museums and monuments all sorts of events both majestic and mundane related to French history" (Barham 2003:132). This shift is mirrored in the assumptions of protectionist labelling schemes in Europe, through which producers may "employ the concept of *terroir* so as to unwittingly conceal and marginalize the historicity of social relations upon which the production and consumption of wine is based" (Ulin 2013:67). This suggests the use of *terroir* policy schemes as tools of governance, "leading to homogeneity and rootedness, while supplying a means for individuals in localities to respond to globalization" (Demossier 2011:685).

It has been well-demonstrated that the historical dominance of Western European wines is more a matter of political history than the blind luck of superior climate or soil mineral content (see for example Ulin 2013, Demossier 2011). Yet, according to the EU Commission, those applying for quality labels must make their case through a link between place and product: "The link must provide an explanation of why a product is linked to one area" and detail "how far the final product is affected by the characteristics of the regions in which it is produced and not another…" (EU Commission 2004:13). However, what evidence counts in proving this link remains a point of debate. In the modern, regulated *taste of place*, the borders of place (and, indeed, its contents) are thus often subjects of contestation, both within and without regions of production. According to Article 22.1 of the TRIPS agreement, methods must exist to verify *typicity*, "such as taste testing (e.g. coffee, wines) and laboratory analysis to identify chemical markers (oils in cosmetics/cheese) […] this is understood as requiring a *causal* connection between product quality or other distinctive features and the region of origin" (Gangjee 2013:233, emphasis added). The emphasis on causal connection between quality of product and its place of origin—for centuries an assumed, myth-like connection—must now be made visible through modern science and technology.

d. Identifying causality in *terroir* agro-ecosystems

Terroir is understood by many farmers to be an empirical, material feature of their land (e.g., Trubek 2008), and environmental scientists have attempted to identify the biophysical mechanisms of *terroir*-expression in specific food products on the basis of climate, soil chemistry, and a variety of other factors (see Goode 2006, Wilson 1998), particularly since the 1960s. This attention to soil, climate, topography, and geology in the growing of grape vines (namely, *Vitis vinifera*) dates as early as ancient Egypt (Falcetti 1994), and wine merchants in ancient Greece were known to label amphora by their point of origin (Bresson 2015:360). However, as one Australian pedologist writes, "[m]ost scientists admit they cannot express quantitatively the relationship between *terroir* and the characteristics of wine produced from that *terroir*" (White 2003:3). Undoubtedly, there are environmental factors at play, however (un)quantifiable: Champagne (protected as a PDO) may pass consumer taste preferences if produced in nearby Spain, however, the making of Champagne becomes impossible in Alaska or the African Sahel; this is not over fussiness of taste or technicality but limiting environmental factors. Given all the grey area, debates around the materiality of *terroir* often hinge on where to draw this (literal and figurative) line between area of production and the outside.

James E. Wilson, in his book *Terroir: The Role of Geology, Climate and Culture in the Making of French Wines* (1998), describes *terroir* as a buzzword (see FIGURE 26), increasingly invoked in the English wine lexicon. He cringes at the often “lighthearted use” of the term, which “disregards reverence for the land which is a critical, invisible element of the term.” He goes on to elaborate on the nature of *terroir*:

> The true concept is not easily grasped but includes physical elements of the vineyard habitat—the vine, subsoil, siting, drainage, and microclimate. Beyond the measurable ecosystem, there is an additional dimension—the spiritual aspect that recognizes the joys, the heartbreaks, the pride, the sweat, and the frustrations of its history. (55)

In wine production, he argues, the landscape ‘‘should be allowed to be itself and produce the wine for which nature endowed it’’ (p. 55). Wilson’s foregrounding of “physical elements of the vineyard habitat” against a background of immeasurable human factors is a fairly mainstream explanation.

Jaime Goode’s *The Science of Wine* (2006) explains *terroir* as a host of ecological processes, where cultural interventions are footnotes. Through these approaches, *terroirs* are often classed using ranking systems, where the best or worst wine-making geographies are ranked according to elevation, slope, aspect, as well as drainage, soil depth, and available water (Jones et al. 2004). Varietals, while perhaps more plastic than geographies themselves, are also considered to be well-suited for particular terrains, ripening times, etc.: an increasingly important factor as inter-annual climate fluctuations continue to increase (e.g., Jones and Goodrich 2008).

FIGURE 26: "Buzzword"? Google Ngram of "terroir" since 1700

Attempts to quantify the physical linkages between geographies and relative tastes have become the focus of agricultural research programs worldwide, from the eminent labs of University of California at Davis, where pioneering oenological and viticultural research has changed the face of wine production since the 1960s, to notable Australian, South African, and various European laboratories, both private and public/university-based. Anesi et al. (2015) describe this proliferation of research as an "increasing interest to define and quantify the contribution of individual factors to a specific *terroir* objectively". These programs produce data that inform newer predictive models aimed at "improving quality and typicality of wines and consequently its value" (Sarmento et al. 2006).

One prominent strand of inquiry currently gaining momentum involves the microbial forces at play in the vineyard. In their recent paper, Anesi et al. (2015) offer their "scientific interpretation of *terroir*" through *terroir*-specific effects on the transcriptome and metabolome of a grape varietal (Corvina); metabolites, found in grape berry flesh, are responsible for flavor compounds and are highly plastic (easily effected by local environmental conditions). Bokulich et al. (2014) present further evidence for material *terroir* through "microbial biogeography", where patterns in microbial diversity across viticultural zones may account for the quality and appreciation of wine products, as “grapes are transformed into wine through microbial activity” (139). They acknowledge that “determinants of regional wine characteristics have not been identified,” but their work serves to challenge common assumptions that these characteristics come from “viticultural or geological factors alone” (139). Their findings suggest that identifiable “microbial assemblages are correlated to specific climatic features”; in short, vineyard conditions (which are themselves shaped in part by underlying geology) influence the microbial inputs, “posing the existence of nonrandom ‘microbial *terroir’* as a determining factor”.

Microbial inputs, particularly the role of naturally-occurring yeasts, have recently come to the forefront of *terroir* research in wines and other fermented products (see for example Capozzi et al. 2015, Drumonde-Neves et al. 2017, Gerhards et al. 2015). In wine-making, fermentation is induced using several methods: batches of must (grape juice with skins and stems) are either 1) inoculated with commercial yeast; 2) inoculated with native yeasts (cultures grown from naturally-occurring, in-situ samples); or 3) not inoculated, allowing only spontaneous fermentation through yeasts already present on the grape/occurring in the production space. However, researchers found that even traces of commercial, house yeasts present in large wine production areas are far more dominant than once thought: in one study, “regardless of which yeast started the fermentation—indigenous or otherwise—a dominant commercial strain took over during the process, essentially wiping out any other forms of yeast that might have been present” (Perdue 2013 summarizing Barrajon et al. 2010). Findings such as these question any definition of “wild” or “natural” winemaking, and suggest that many “naturally” occurring yeasts are quite possibly the progeny of dominant, “escaped” commercial yeasts, what some wine makers call “domesticated”. Not to be discussed at length here, mycorrhizal fungi are also known to form symbiotic relationships with grapevine roots, adding to a growing wealth of literature on the invisible, living forces at work in wine production (Trouvelot et al. 2015).

Another theme among "scientific interpretations of *terroir*" include quantitative frameworks for diagnosing or reverse-engineering geospatial *terroir*, such as Natural *Terroir* Units (NTUs). NTUs have been proposed for outlining boundaries of *terroir*, or physically ideal and relatively homogeneous landscapes for agronomic production relative to certain crops (Laville 1993). An NTU is thought to be irreproducible, difficult to modify, and highly complex. This complexity is thought to result in distinctive food crops, which "cannot be viewed in isolation from management and cultivation practices" although management and cultivation—the human factor—"do not form part of the intrinsic definition (of *terroir*)" in this context (Carey, Archer, and Saayman 2002: 1). As Priori et al. (2014) explain, mapping NTUs involves a careful consideration of the biosphere through analysis of these stable variables; while there are numerous methodologies for studying the agronomic relationship between these variables, the purpose of the NTU is more basic: to first isolate a geographic region and quantify its *terroir*. This informs even more recent moves toward precision viticulture: as in other precision models of agriculture, this utilizes very high-resolution, "big data" to prescribe management decisions and optimize a given *terroir* unit.

These are merely a few, non-comprehensive examples from the vast amount of research across the environmental sciences seeking to identify and "fingerprint" the material features of *terroir*, where new, often conflicting, studies seem to appear with each month. Unsurprisingly, there is an equal and growing opposition from *terroir* "skeptics" seeking to debunk "*terroir* and other wine myths" as "junk science"—merely a marketing ploy (Matthews 2015). The role of taste panels in determining quality and consistency have also shown mixed results at best, where "many wines that are viewed as extraordinarily good at some competitions are viewed as below average at others" (Hodgson 2009:1). Another study identified a strong bias amongst expert wine judges between red and white wines that was ameliorated through the use of opaque glasses, and also found that laypersons could not tell red wine from white wine when dyed with odorless pigment (Morrot, Brochet, and Dubourdieu 2001). In yet another example, consumers were found to prefer wines perceived to be expensive, taste being tied to a sense of economic value (Goldstein et al. 2008).

In a controlled study, price and country of origin were found to be more important contributors to perception of wine quality than taste perception: the authors thus conclude that "marketers cannot assume that intrinsic product attributes, even when experienced, will be weighted and interpreted accurately by consumers" (Veale and Quester 2008). Certainly, working definitions of *terroir* to date have not included bottle prices, glass opacity, or the background music played at time of consumption (another decisive factor in wine appreciation according to Spence and Wang [2015]), yet these are only a few of the ways in which human experiences of wines—and thus appreciations of *terroir*—are mediated by extrinsic, cultural forces.

Naturally, seeking the *absence* of *terroir* mechanisms is futile—essentially, this would be proving a negative. Using the STS lens and the idiom of co-production outlined above, I turn instead to develop a picture of the contexts in which the science of "*terroir*-making" occurs, taking scientific knowledge not for granted, but as informed by broader cultural contexts: political and ideological legacies, global market demands, and shifting taste preferences. It should be clearly reiterated, as I present this case study, that I am not seeking to engage with these two sides of the same coin, but rather seeking to offer a new accounting of *terroir* as an artifact of social-scientific and material processes, a social-ecological system.

III. THE PLACE (OF TASTE)

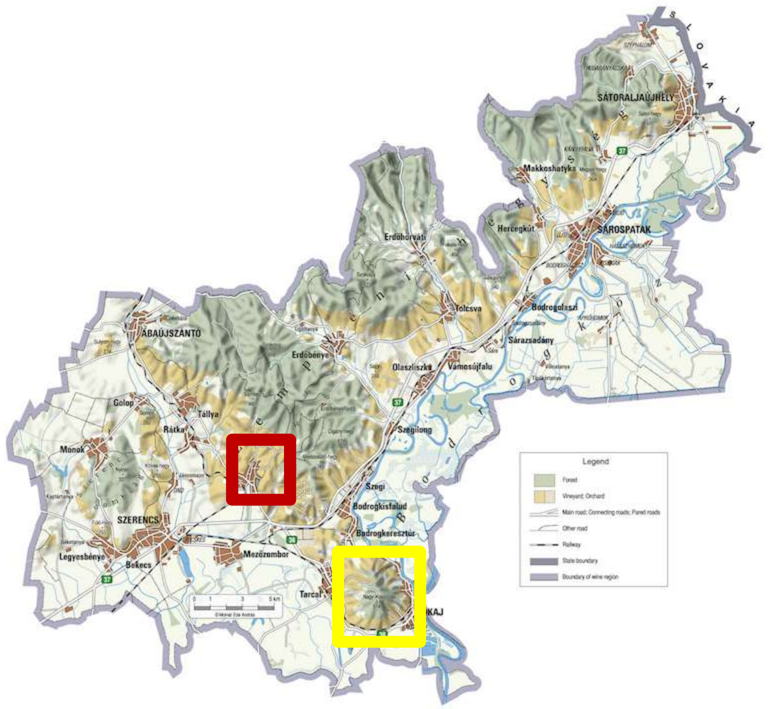

FIGURE 27: Map of Tokaj wine region (with Hamvas village and surrounding area in red, Tokaj village area in yellow)

a. Tokaj, Hungary

Hungary is a key wine-producing country in the Central and Eastern European (CEE) region, often dubbed the "New Old World". The first written record of wine production in Hungary dates to the 5th century CE, and, perhaps because it is located on migration routes between the origin of winemaking (the contemporary Southern Caucasus) and the continent of Europe, Hungarian is one of only three European languages in which the word for wine (*bor*) is not rooted in Latin. By the 1600s, winemakers in the Tokaj region of northeast Hungary (FIGURE 27) determined that its best wines consistently came from a specific set of growing tracts and created the first modern classification system of its kind in 1737, dividing each zone of production (*dűlő*) into three quality classes based on a number of environmental and economic variables, helping to standardize the production of its primarily sweet white wines (for which there were stable demands throughout central and western Europe, as well as Russia). This regulatory act made Tokaj the second oldest (proto) PDO in the world (the protection of Chianti in Italy predated this decree by 41 years). Within this century, wines from Tokaj received world acclaim as the region profited from a thriving international trade. Notably, France used to import Tokaji[9] wines, where King Louis XV called the Tokaji aszu (a honey-like, sweet wine) the "Wine of Kings, the King of Wines". It eventually became the famous favorite of Napoleon, Beethoven, and Roosevelt, enjoying international status. However, the "sweet nectar" of Tokaj (mentioned even in the national anthem of Hungary) all but vanished in the twentieth century during an era of supply economics: quantity-based production and bartering-type trade arrangements with the U.S.S.R. and other bloc countries (Liddell 2002).

Following the transition period that began in 1989 as the collapse of communism reverberated throughout CEE states, the contemporary Tokaj region provides a timely and ideal site in which to examine *terroir* at the nexus of the socio-political and ecological. Today, the official Tokaj region, or Tokaj-Hegyálja (Tokaj Hillcountry) includes 27 towns and villages in Borsod-Abaúj-Zemplén county and their surrounds. Here, a new generation of winemakers seek to revive, or perhaps reinvent, the region in the contexts of a globalized food system unfamiliar with the once-popular "Wine of Kings". In this wine region, the legacy communist production is simultaneously ideological and material—transcribed onto the reconfigured vineyards themselves, producing wines now unfamiliar to many outsiders: a landscape that begs for translation.

[9] *Tokaji* is the adjectival form of *Tokaj*.

b. Methodology

This chapter foregrounds one case study in the Tokaj region that emerged through data collected over the course of 14 months of ethnographic fieldwork (June 2015, September 2016—November 2017) in the Tokaj region and Budapest, Hungary. This included a two-week environmental survey period in Tokaj and Hamvas village areas during summer 2015. The decision to utilize informant-led environmental sampling grew out of preliminary research and exploratory fieldwork in the region (2011 and 2014), which suggested the importance of environmental narratives in place branding in regional wines, in particular, the role of soils in the history of the Tokaj region. My background in environmental anthropology and status as a graduate student in a crop and soil science department provided the opportunity to follow this thread of inquiry as one off-shoot of a larger dissertation project, complete with an interdisciplinary committee with expertise in anthropology, soil chemistry, and agricultural sciences.

i. Environmental Sampling and Analysis

During summer 2015, eight vineyard tracts (each with subdivisions) were selected for soil analysis, documentation of slope, aspect, altitude, and note of any visually distinctive features, including vineyard management practices. Areas to be tested were defined by informants, which were then sub-divided based on vegetation and soil characteristics (also led by informants). Soil sampling involved walking in a "zig-zag" approach to take approximately 8-10 samples from each of these sub-zones. Producers were asked to give tours of their vineyards, presenting areas in which they perceived differences to exist (while this was presented as an open-ended question, these differences were always explained as soil- or soil/slope-based).

Soil sampling involved stratified random sampling of the entire vineyard where composite samples of each zone were collected. Composite samples included the collection of 8-10 samples to a depth of 10cm using a 20cm auger and represented areas between 0.15 and 1 hectare. In addition to these 0-10cm samples, a second stratum was sampled at 10-20cm using a trowel or shovel (to create a larger hole to view any striations or anomalies in the soil profile) and a 20cm auger. Analyses later showed no significant differences between the 0-10cm and 10-20cm soil depths, suggesting uniformity in the solum which, in almost all vineyards sampled, was exceptionally thick. Soil samples were packaged and shipped to The University of Georgia's AESL in Athens, Georgia (USA) for Mehlich analysis, which provided data pertaining to available macro nutrients, as well as pH and percentage organic matter. These tests, which are commonly done by farmers and gardeners around the world prior to planting (including producers in the Tokaj region), not only provided some insight into the material differences between Hamvas and Tokaj village soils, but also served as a prompt via participant observation, giving critical insight into the *terroir* "logic" of producers. This information informed future interview rounds in the region.

ii. Ethnographic Data Collection and Analysis

The purpose of the fieldwork was twofold: first, to complete a comparative soils study of two sub regions within the Tokaj-Hegyálja wine region of Hungary, utilizing best practices and standard methodologies for agri-viticultural soil tests, and second, to pair these data with ethnographic data collected in-situ to account for the minerality concept in viticulture through the lens of science and technology studies. Together, these two approaches represent two paradigms essential to the research question: a value-neutral agricultural science approach and a social studies of science lens, respectively, with ethnographic data contextualizing the soils analyses.

This research foregrounded a participatory approach, which pairs well with the research question and to the science and technology studies framework of analysis: rather than predetermining which vineyards to sample, or the boundaries of the sampling sites, my aim was to *participate* in and *observe* those very decisions as they typically occur at these sites. This allowed me to get into the rationale of producers (the decision-makers) rather than import a, perhaps more systematic, sampling regime. This approach is similar to that of *citizen science* (Kimury and Kinchy 2016) in that it is *participatory*; however, while many participatory methods engage the "lay public" in the implementation of wider scientific studies (often as instruments of observation—counting birds, for example), my aim was to involve producers with all of their local knowledge in the design of the research (soil survey) itself. This provided insights that would have been unafforded by traditional approaches, and prioritized data pertaining to the research question (i.e., the creation of *terroir*-related knowledge).

Thus, producers were asked to give tours of their vineyards (or rows within vineyards, as most parcels are shared between multiple owners), presenting areas in which they perceived differences to exist (additionally, dividing vineyards into zones based strictly on varietal type was not a feasible consideration due to the heterogenous layout of grapevines within vineyards). These delineations occurred without prompt in many cases; for example, one producer was very enthusiastic about having five types of loess in his single, small vineyard and chose to present it specifically for this reason. His assessment of his vineyard's diversity of soil types was based on the visually different colors and textures of the loess soils. In cases such as these, each "zone" was sampled as defined by the producer (in this case, by color variation). For the soil sampling round, eight tours of as many vineyards[10] were completed (five in Tokaj village with three producers; three in Hamvas[11] village with two producers).

The environmental sampling outlined above included informant-led walking tours of vineyards during sampling with producers/consultant and included a series of open-ended

[10] Referred to in later sections as *dűlő*-s, although the terms are not exactly synonymous, as discussed below.
[11] Hamvas village is a pseudonym.

interview questions pertaining to the management and history of each tract. These interactions were audio-recorded and photographed. Marketing materials were also collected from both Tokaj and Hamvas villages as part of the summer 2015 study, including publications by the Hamvas Roundtable discussed below. Notes (jottings) were written in the field, while detailed fieldnotes were expounded upon following each tour/interview/soil sampling event.

As part of a larger doctoral dissertation project, a series of wine festivals, events, harvest activities, lectures, and tasting courses were attended and participated-in, audio-recorded, and photographed when possible over the course of fourteen months. These data, collected 2016-2017, provide context for the case study presented in this chapter and are referenced for context, although to a much lesser extent.

Speaking to the co-production of soils knowledge, I will employ a convention designed to keep laboratory data and discursive data in conversation: following sites of production mentioned in the text, a series of values will follow in the footnotes, e.g., *2.5Y 4/4, pH 6, 3 mg Kg-1 K, 8 mg Kg-1 P, 2% OM*. These values represent the Munsell color reading, pH, available nutrients (in milligrams per kilogram), and percentage organic matter. Where the conversation refers to an area where more than one sample was collected, an average is used. It should be stressed that these data do not serve to *qualify* interview data, but rather to add an accompanying snapshot through another lens, simultaneously.

IV. A HISTORY OF PLACE-BASED TASTES IN TOKAJ

a. The *dűlő* as site of *terroir*

The Hungarian *dűlő*, roughly translated for English speakers as "vineyard-tract" refers to "as section of land designated by name as a single wine-growing *spread*…. in general agricultural usage [*dűlő*] signifies 'field', but in wine-growing usually approximates the French term *climat*"

(Lambert-Gócs 2010:132). *Climat*, like *dűlő*, hinges on *terroir* (sometimes called *dűlőmitológia* in Hungarian), or "how the intersection of climate, soil type and topography influence the way a wine turns out" ('Dr. Vinny' at the Wine Spectator, n.d.). The *climat* or *dűlő* is thus the spatial manifestation of *terroir*.

What makes the Hungarian *dűlő* concept especially significant is its historical and political context: despite monumental changes and challenges in Tokaj's recent past, producers still reference *dűlő*-s as a primary feature of wine-making, for example, in looking to purchase tracts within a particular *dűlő*, or buying a neighbor's grapes from a historically great *dűlő*, or more recently, producing single-*dűlő* wines in order to showcase the land's potential itself (this runs parallel to other single-vineyard or single-origin beverage trends, as in coffee).

While the *dűlő* has remained constant for centuries, little else in the region has. Originally a hub of sweet wine production from white grapes using a fairly standardized methodology (particularly in making the famous *aszu*: botrytized sweet wines), today's Tokaj production is much more fragmented, with most producers focusing on dry or semi-sweet wines in accordance with global market demands. While this has inspired a wave of experimentation within the confines of the current EU-level Protected Designation of Origin (PDO) law[12], it has also led to a great variety of ideas around future directions for the small region. The borders of Tokaj constitute an 11,149-hectare landscape (equivalent to about one-third the area of Atlanta, Georgia), with roughly half of that area under wine cultivation (production area having declined since 1989). The recent tendency of Tokaj's small-to-large scale producers to head in many different (often opposite) directions (for example, mass-production versus small batch, or dry, sweet, or sparkling wines, or exclusively aging in barrels versus stainless steel) was described by one winemaker described as

[12] A number of local and regional rules also apply, including recent village-level, membership-based quality schemes, some of which are touched upon in this chapter.

frustrating and futile, as if "going to the hairdresser and cutting only part of your hair out of indecision" (D at TY Winery). Thus, after two world wars, a devastating 19th century phyloxera epidemic, four decades of communism and a post-socialist transition that has left many countryside residents ambivalent, for producers, it is the *dűlő* that remains at the heart of both commercial and hobby winemaking in Tokaj, even as the most basic components of winemaking tradition and method—indeed, even as the aim of the region—remain contested.

b. *Dűlő* classification in Tokaj

Historic narratives of environmental quality have played into the legality of branding ecologies as intellectual property (Gangjee 2013), protecting local *terroir* or the "taste of place" for consumers across an expanding global foodscape. While the concept of unique, locational products is perhaps as old as agriculture itself, the modern legal classification and protection of geographies for this purpose arguably originated in 18th century Hungary. This is described by historian Mátyas Bél in his text *Magyarország Népének Élete 1730 Táján* (*Hungarian Folklife Around 1730*) (Bél 1984). Having never set foot in the Tokaj region, and written originally in Latin, Bél used geological maps to remotely outline the qualities of first- and second-class *dűlő-s*—also taking into consideration factors such as prices fetched for wines from each plot. He cites wine fraud as one motivation: "many are called Tokaji, which are not, and many in turn refuse to [be called Tokaji], which belong" (388).

Bél describes at length the "specialties of the soil", though technologies of his day were limited to long-term visual assessments and anecdote-based conjectures. "There is no other wine region that is better located with respect to climate," he explains, because the south-facing hill slopes face a great plain, allowing for maximum warmth and sunlight (this trait, he says, was also appreciated by the Romans—the earliest winemakers in the region).

In another section, he asks, “From what arises the wine’s primary excellences? Soil, stone, or something else?” This is answered in the first line: “the excellence of the wine is owing to the excellent soil and landscape”. He explains that the soil derives its advantages from intermingling stones and “tuff gravel”, which “give goodness to the soil, and retains coolness” (Bél 1984:400). Whether blanketed in the ash-like or the harder, red and black stony earth, all of Tokaj is “endowed with good qualities,” and its soils “transmit neither saltiness, nor bitterness, but *sweetness*” (400, emphasis added).

The Tokaj-Hegyaljai Album (Szabó and Török 1867) is the second landmark in the canon of foundational Tokaji texts—a notable turning point that references and bolsters the claims of Bél’s 1730 works. It provides a collection of scientific and ethnographic articles, illustrations, maps, and tables commissioned by the Tokaj-Hegyalja Vinicultural Association to “…make known to the civilised countries the birth place of the far-famed Tokay wine; to show with what prodigality of beauty and grandeur Nature has endowed the place where the king of wines, has fixed his throne” (3).

The “powers of nature, mind, and labour” are said to form the basis of wine cultivation in the Tokaj region, which are then outlined from an “ethnographical, geographical, geological, agricultural, botanical and chemical point of view” (3). With arguments that seem strikingly modern, the album laments the “unknown” status of Tokaj’s landscape:

> What preposterous notions must have prevailed in a political, financial, and mercantile point of view, that the great fertility of our country […] should have remained unknown for centuries, and though situated in the centre of Europe, should have been as it were discovered only in our days. (5)

The authors contend that this is the fault of “men of letters”: there has yet been no attempt to introduce the Tokaj region *systematically* in order to counter outsiders’ “preposterous opinions about Hungary” (Szabó and Török: 5). This Tokaj Album, therefore, introduces winemakers’ recent turn toward a “more rational cultivation of the vine”, hoping that the press will aid their campaign so that knowledge of Hungarian wine districts will spread outside the region (5).

The Tokaj-Hegyaljai Album makes it clear that champions of the Tokaji wines were, even in 1867, feeling the tension around the disputability of quality geographies. The project of the Tokaji Album, then, was to undermine “prejudice” against Tokaji wines with rational, scientific discussion of Tokaj and its quantifiable goodness; in other words, to override and perhaps win over subjective opinions through a novel, more absolute language of argument: agricultural sciences. This included: descriptive geology of the region and formations (sedimentary and clastic), soil typologies (descriptions of clays, loess, among others) and their parts (FIGURE 28) and chemical analyses of 41 donated wines, comparing villages to one another and determining no basis on which to distinguish village-level wines. There is also a soils analysis portion, which includes measurements of density, absolute weight of samples, the same when wet, the water holding capacity, cohesion (potter’s clay used as standard), and others (138-143).

D.

TABLEAU DES PARTIES CONSTITUANTES

DES SOLS DE TOKAY-HEGYALJA.

	Séparément – Soluble dans l'acide chlorhydrique: KO	NaO	CaO	MgO	Al^2O^3	Fe^2O^3	PO^5	CO^2	SiO^3HO	SiO^3	Total	Parties in-solubles	Parties volatiles – séparément: Humus	mat. organ.	Total	il y en a: -N	-C	Total
α. Argile plastique.																		
I. Zombor, Kir ály.	0,181	0,304	0,671	0,179	10,395	8,076	0,251	—	1,850	3,879	25,911	64,889	4,600	4,600	9,200	0,285	2,76	99,901
II. Liszka, Meszes.	0,176	0,617	0,709	0,149	8,706	9,473	0,031	—	1,000	9,526	30,439	64,561	2,220	2,780	5,000	0,067	1,332	99,948
III. Zsadány, Elő-hegy.	0,446	0,911	0,408	0,138	14,578	7,886	0,080	—	2,366	7,678	34,541	55,059	5,013	5,387	10,400	0,229	3,006	99,950
IV. Ujhely, Várhegy	0,568	0,698	0,115	—	6,365	4,742	0,027	—	1,216	9,093	22,824	74,171	2,297	0,703	3,000	0,034	1,378	99,995
β. Loëss.																		
V. Tarczal, Szarvas.	0,254	0,443	2,050	0,257	10,373	7,457	0,216	1,604	1,978	2,343	26,975	62,304	4,497	6,103	10,600	0,341	2,69	99,879
γ. Ponce.																		
VI. Erdő-Bénye, Pe-res.	0,273	0,643	0,372	—	8,257	5,384	0,080	—	1,186	1,516	17,812	[illegible]1,588	3,750	6,850	10,600	0,045	2,250	99,898
VII. Ujhely, Oremus.	0,279	0,584	0,365	—	5,702	5,018	0,033	—	1,311	6,800	21,112	72,888	—	—	7,000	—	—	99,980
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
	Singly – soluble in muriatic acid: KO	NaO	CaO	MgO	Al^2O^3	Fe^2O^3	PO^5	CO^2	SiO^3HO	SiO^3	Sum	Not soluble	Volatile parts – singly: Humus	organic matter	Sum	therein: -N	-C	Sum

TABLE SHOWING THE CHEMICAL COMPOSITION

OF THE SOLS OF THE TOKAY-HEGYALJA.

FIGURE 28: 1867 chemical analysis of Tokaji soils (with V. being most representative of Tokaj and IV. being most representative of Hamvas) (1867:147).

The writers trust that, through these analyses, "the veil will be lifted which has so long mysteriously concealed from the greatest part of Europe the cultivation of Tokay wine" (5)—a metaphor that would be revived many generations later. It is not without irony that, a century after this publication, the "miracle of Tokaj" would be again concealed by an iron curtain that figuratively and literally separated the region once more from the greater part of Europe.

While the 1867 Album attempted to revive the region after political hardships and resulting "prejudices", Tokaj's troubles were far from over. In the 1870s, the arrival of phylloxera (a louse that thrives the rootstock of *Vitis vinifera*) dealt Tokaj a significant blow, destroying 60% of Hungary's grape vines by 1897 (Halász 1981:43); rootstocks have since been replaced with resistant, North American varieties. Finding itself on the losing side of two world wars in the 20th century, Hungary also lost over two-thirds of its territory to neighboring countries (under the Treaty of Trianon of 1920), including a portion of the Tokaj region. Later, thousands of Tokaj's Jewish inhabitants, many of them central wine producers and traders, were sent to Nazi death camps in 1944 during the brief fascist interval that preceded four decades of communism. The years that followed saw collectivization of wine production under the state, and by 1949, wine exports resumed—this time, with the Soviet bloc under the Warsaw Pact. Collectivization plans following the revolution of 1956 were designed to contribute to industrialization; perhaps paradoxically, Hungary's wine industry benefitted from these policies (Liddell 2002:12). Mechanization increased production, and allowed laborers to contribute to burgeoning industry, and "wine became a significant export under what was essentially a barter system" between Hungary, the USSR, and its satellite states (12). It was during this period especially that quality is reported to have dropped in favor of quantity-over-quality modes of production.

The conclusion of communism in 1989 arrived with its own host of complications. The "Wild East" of the 1990s witnessed the buying up of newly privatized business—and Tokaji lands, now incredibly cheap—by internationals with funds. The transition brought with it a chronic lack of capital, which is especially present in rural areas even today. This situation that has limited producers' investment, not only in modern advancements (as in novel winemaking technologies) but has also prevented them from returning to an idyllic past (as in re-shaping vineyards to include terraces, the traditional method of cultivation, rather than the wide rows created during socialism that allowed for mechanization)—the result is a region in limbo. As wine writer Alex Liddel asked, "How does a country with once-proud wine traditions reinvent itself after forty years of Communism, during which the entire structure of grape-growing and wine production was changed out of recognition?" (i).

The once-famous wine region, now diminished in size and global standing, is today the site of reinvention and innovation. Approximately 300 winemakers produce within the official borders, from hobby producers with family cellars to large-scale, modernized wine estates, with a small minority of those producing for export. Having joined the European Union in 2004, Hungary is again a key wine producer with increasing output to Western Europe, North America, and growing East Asian markets. Yet, for all its historic claim to superior wines, the perennial problem of place-based recognition persists in the "unknown *terroir*" of post-socialist Europe (Jung 2014). Today, Tokaj (or *Tokaj-Hegyálja*, Tokaj Hillcountry) can be used legally for any sweet, dry, or sparkling wine produced in the 27 communities and their surrounding hillsides. As I will present below, the contemporary professional wine scene in Tokaj is fueled by speculations on *terroir*, turning once again to scientific expertise to "lift the veil" on the innate quality of its very landscape.

V. MAKING MINERALITY

a. The "secret of Tokaj"

I met András[13] during the summer of 2015 at his family's estate in the village of Hamvas. As an 18th generation winemaker, he has separated his enterprise from his father's renowned winery and is among the "new generation" of Tokaji vintners: the first generation of post-communist era production characterized by a forward- and outward-thinking approach. His face is seen on the many glossy black-and-white pamphlets that litter local tasting bars and hotels, where visitors can read through his guiding philosophy. Upon introduction by a mutual acquaintance, he agreed to tour me around several of his *dűlő*-s and participate in a soil sampling excursion.

Unlike his father, whose self-named winery is among the most famous in Hungary (and, increasingly, outside of Hungary as well), András has named his own wines after an especially

[13] Pseudonyms used throughout.

historic local *dűlő*, and his logo is a minimalistic rendering of a pile of stones. What he does share with his father is a passion for quality above quantity that, he argues, is solidly grounded in the terrain itself: a variable he says is "like the idea on the X-factor on TV". He explains that, while everyone on the show can perform—and as all Tokaji producers are able to make table wines—"there is only one guy with the X factor". The *dűlő*, according to András, brings the "X-factor".

FIGURE 29: András and the author look over some first class dűlő-s around Hamvas (an area his family distinguishes from the rest of the Tokaj wine region due to its "geologic possibilities", evidence of which we are standing on). Photo by Dan Adams.

András and I headed out to one of the hills above Hamvas village in his truck, which easily climbed the muddy paths to a rocky lookout point flanked by vineyards (FIGURE 29). He led me through the rows, explaining the qualities of this particular *dűlő*[14] and determining from which areas our soil samples should come. His detailed local knowledge of the land proved to be not only

[14] pH 7.3, 5YR 4/4 and 10YR 3/6, 2843 mg kg-1 Ca, 303 mg kg-1 K, 227 mg kg-1 Mg, 50 mg kg-1 P, 17.0 mg kg-1 Zn, 3.5% OM

spatial, but deeply temporal. This became apparent as we rounded one sampled area, and he suggested a second site of comparison:

> Author: It seems like it's more red here.
>
> András: Yes. And drier. See how dry?
>
> Author: Oh wow, yeah. What about the water from underneath—the water table? Is it – does it come up very high?
>
> András: No water table here [...] because these volcanos are young, some of the youngest in Europe. There was no time after the volcanic activity to create sedimentary layers. That's why the zeolite, which is created between the rocks in the cracks, it's very important.
>
> …the zeolite is created from heat as popcorn is created from corn: the weight is the same but the surface is much bigger. And by the surface activity, these minerals can hold the water. The roots of the grapes follow these minerals, and the small pieces in the surface are small enough to cover the root…. *This* is the secret of Tokaj, in a sentence.

The "secret of Tokaj", according to András, is in the cracks: the cavities that formed in the rhyolite 4 million years BP when Tokaj was a region of water and fire—lakes with active, volcanic islands.

FIGURE 30: András and the author take samples from a Hamvasi dűlő*, where Furmint [varietal] grapes grow on "the most expensive agricultural land in Hungary". Photo by Dan Adams.*

The hills around Hamvas were once these volcanos. While most hills around Tokaji villages are also volcanic in origin, they are different in that they are blanketed in aeolian loess (the ash-like soil mentioned by Bél centuries ago). Without this blanket, Hamvas resembles a Martian landscape, red and rocky (FIGURE 30), with colorful stones that “decorate the vineyard” (Bél 1984 [1730]). It is no wonder that distinction of taste would be linked to these obvious differences in topography, inspiring a collaboration between András’s winemaking family and the geology department of a local university, who are carrying out an extensive research project, drilling into hillsides for core samples.

The cracks not only make rhyolite a sort of sponge, helping grapevine roots access water through capillary action, but are often filled with zeolite to create what András points out as “small, greeny holes”.

FIGURE 31: Zeolite-filled rhyolite tuff in Hamvas.

To illustrate this point, he takes me to a local mine[15] where it is possible to view the entire profile of a hill that has been blasted and is covered with vegetation:

> The plants really like to live in this stone, because all the holes filled by the zeolite have water. It looks like a rich soil, but there is no soil. Only zeolite. And if you see the top, it’s full of bushes and everything, so, the plants really like this place.

He explains that there are three identifiable types of bedrock, or parent material, that dominate in the Hamvasi *dűlő*-s and from which local soils are derived: andesite, rhyolite, and dacite. The

[15] pH 8.4, 2.5Y 8/3, 6702 mg kg-1 Ca, 110 mg kg-1 K, 690.8 mg kg-1 Mg, 5 mg kg-1 P, 0.1 mg kg-1 Zn, 1.8% OM

region's dacite is often covered by loess (as on Tokaji Mountain), while rhyolite and andesite is covered by clay.

His observations and his ability to taste the differences between various Tokaji and Hamvasi *dűlő*-s have inspired him to *remineralize* his *dűlő* soils with rhyolite mined locally, as he tells me: "…when we [plant] new plants, we add half or 1 kg of this rhyolite, because it keeps oxygen, too, and by the surface activity, the water, too." The results of their observations and surveying have also led him and a team of over 20 winemakers in his village to spearhead a new labelling scheme, one that breaks with the history and reputation of the Tokaj region and redraws the parameters of quality exclusively around the volcanic hills of Hamvas village.

b. Minerality goes political: The Hamvasi Roundtable

András's father, Janos, takes the volcanic/loess divide to heart. Along with his son, Janos leads a roundtable of winemakers in Hamvas village to showcase the volcanic soils of local *dűlő*-s, going as far as creating a separate label of origin that relegates the Tokaj region to a footnote and brings Hamvas village (or even the *dűlő*) name to the foreground. Janos, one of Hungary's most famous winemakers, is optimistic about the ability of recent scientific and technological advances to better understand what makes a quality *dűlő*—by core samples drilled from the original, first class *dűlő*-s. He refers to the 17th century classification system outlined by Bél (1984 [1730]), which he sees as *finally understood* through contemporary studies:

> Janos: It was written which [*dűlő*-s] were the best ones, but they did not know exactly why a few hundred years ago. They wrote about the soil, ok, but they did not know too much about the subsoil, about the minerals—the *kinds* of minerals, the drainage, and so on.
>
> Author: And now we know? A little more?

> Janos: More or less. Yes. I've been studying this here since '98. And more and more I've the met people, professors, several times who are responsible for the [geological] research [undertaken in local mining and manufacturing sites] …they made thousands of drill holes. Many, many, for 15 years, continuously.
>
> And we do it too, but we do it in a different way. Because they wanted to know the lower level. The bedrock. We want to know how *varied* it is—a quite different point of view.

Janos represents the view of many Tokaj winemakers: that objective determinants of quality and good tastes lie in the composition of a *dűlő*'s geology; quality winemaking is about letting them shine. As inhabitants of the most prized *terroir* in Tokaj, they see themselves as uniquely positioned to create the most distinctive wines, turning toward dry wine production (now 70% of production), which better showcases the *terroir* and is exportable, being en vogue in international markets.

Janos now works with a local university to spearhead geological research in his *dűlő*-s to learn what makes the physical *terroir* of Tokaj unique; he uses this knowledge to identify quality in the field, explaining, "We have been looking for the *terroirs* where we can realize our goal—that is, to try to make the most complex wines. So we built the property by studying the geologic possibility." Presenting a table of stones (FIGURE 32), he presented a pumice-type of rock:

> …and this is from the *Király Dűlő* [*King Dűlő*]. It's a very, very deep rhyolite tuff with zeolite and mineral clays. […] It's very, very special. When we find this everywhere it is the—it signifies the highest quality at all possible.

As he explains how each rock or mineral signifies a particular wine-making potential, he tells me that there is "no wine region in the world that has such a varied geology, because of the geothermal activity" that predated humanity itself.

FIGURE 32: A display of local survey findings from sites around Hamvas village.

When I ask why the Hamvasi Roundtable seeks to create a sub-region within Tokaj, András, quickly corrects me: "it is not a sub region, but a separate region." He explains the differences between various levels of regulation that apply in Tokaj:

> It is controlled by law…. So, in the European Union you can grow 14 tons per hectare if you want to use the name of the region. You *can* grow more, but you can only write "[produced] in the EU" or something. Or a fantasy name, or something. But in our society, if you produce between 7 and 14 tons, you can only use the name of the *region*; if you produce between 4-7 tons, you can use the name of the *village*—so it's the village level; and if you produce less than 4 tons, you can use the name of the *hill*. And

> here, you can decide what kind of quality you take off the shelf. And it's based on the minerality contents.

András insists that the consumer of his wines will be able to choose a level of quality based on minerality contents. His argument hinges on surface area—not that of the *dűlő*, but of grapevine roots. The roots of a vine, he says, can only transfer what limited amount of nutrients are available, whether it produces 6 or 10 bunches. Therefore, the higher the number of bunches, the more dilute the *minerality*—the *terroir*—of the *dűlő* in the end product. The age of the vine is also a factor, because "at 10 years old, or at 40, 100-year-old plants can bring a different volume of minerals into the bunches". According to his society, "less than 4 tons [per hectare] is the strongest in taste" and warrants use of the hill's name. Growers may also produce 7 to 14 tons per hectare and use the Tokaj name, which he says indicates that "you can taste the Furmint nose, the Furmint taste, but you cannot decide whether it is from loess soil or from the [volcanic] Hamvas area"—rather, it has only a "typical Tokaj taste". With production between 4 and 7 tons per hectare, the village name may be used, as "you can feel some minerality, but it's not so serious."

EU- and state-level laws, which protect Tokaj as a PDO through broad requirements, are too relaxed for the levels of quality sought by András and his cohort (namely, anything made from the six approved varietals, grown within the borders, can be sold as "Tokaji"—including wines made within the now Slovakian portion). Even the original *dűlő* classification documented by Bél is useless without consideration for this *minerality* mechanism (that mineral nutrients lead to quality), he says, if production is too high. Grape production levels under communism reached around 14-20 tons per hectare. "Today," András says, "the quality comes at between 2-4 tons [per hectare]". This claim, according to András, is supported by external factors, such as the tasting notes of critics, or auction selling prices.

c. No room for neutrality

The distinction of Hamvas rests on co-produced political-geological boundaries that separate rocky, volcanic outcrops from the broader, loess-blanketed Tokaj: a binary that was recorded in Bél's early accounts of 1730s Tokaj. Even then, he identified two prevailing soil types. Speaking of what appears to be the fine, loess soils found in most of the Tokaj region, he writes about the first:

> …[the Tokaj Mountain's] south-facing soil is the best in the entire region for grapes. It does not have a firm nature, but rather soft and powder-like, and rather light in color, as opposed to black or red; it is similar neither to sand nor to clay, but rather, to a certain degree, like ash. (Bél 1984:393)

He goes on to describe an abundance of moisture provided by underlying, hard layers that "give strength" to and "magnify" the vines, earning the producers great praise. The second type of soil described by Bél is found only in certain villages, including Hamvas and Tarcal: it is "not so powder-like and soft, but rather solid and hard—and rich; the locals call the soil *nyirok*, because it is almost tar-like […] dense, and very solid" (393). Of the *nyirok* soils, he identifies one red and one black, "both rich and fertile, but the red more advantageous for the grapes" (393).

These differences are visible to the human eye. In one Tokaj area vineyard, winemaker and consultant Dáni presented a local *dűlő*[16], favored for its loess soils, and which included the occasional "*loess baba*"—colloquially, a *loess baby*, or calcium inclusion (FIGURE 33).

[16] pH 7.9, 2.5Y 4/3, 3734 mg kg-1 Ca, 62 mg kg-1 K, 238 mg kg-1 Mg, 78 mg kg-1 P, 6.6 mg kg-1 Zn, 1.9% OM

FIGURE 33: Dáni displays calcium inclusions in one loess-laden dűlő.

Today, in addition to visible differences, producers like Dáni and András use new tools to translate soil qualities. András sees this as not only a sensory distinction (evidenced in the wines' tastes, visual differences in the surface), but is quantifiable as *pH*, pitting producers on either side of the number 7:

> The big differences between the two places? The pH. The minimum [in Tokaj] is around 7, but always—almost always higher than 7. In our area, the next village, the pH is always *less* than 6. And we have a place – it's called Kovago—we just wanted to plant it, and the pH number (because we pre-test the soil, you know, before planting) is 4.2. So [in Tokaj] it's always higher than neutral, and in our area it's always much less than 7. It's a very big difference.

In this accounting of difference, pH serves as a rough proxy for the volcanic/loess divide; top soils that are igneous in origin will reflect this in a lower pH because of the presence of free quartz, which will produce silicic acid as it weathers, contributing to poorly buffered, low-nutrient, acidic soils that are well-suited to high-acid varietals such as Gamay (a half-sibling of Furmint) (e.g.

White 2003). On the other hand, loess is aeolian in origin: silt and sand particles arriving by wind with some clay content (usually 20% or less), lightly held together by calcium carbonate (Donahue et al. 1977). In Tokaj, loess is usually non-stratified and very thick (easily over 15 meters), where ephemeral streams have carved small, canyon-like paths into the hillsides (FIGURE 34). If acidic, volcanic soils signify minerality, then this is the literal litmus test of quality.[17]

FIGURE 34: The author and Dáni stand in a loess gully in Tokaj.

The colors of the rocks and minerals in Hamvas *dűlő*-s bring these differences into view. I witnessed this with András in one especially 'ornamented' *dűlő*[18], "if you look around," he noted, "now that the soil is wet, you can see how varied the color is: grey, brown, red—within a few meters." When I ask whether he could see that the grapes grow differently on each color, he replied, "No, the *taste* is different." In another example, a woman in her 30s whose family has made wine

[17] In our testing, Tokaj sites averaged a pH of 8.224 (range of 7 to 8.6), Hamvas sites 6.6333 (range of 5.3 to 7.4).
[18] pH 7, 5YR 5/4 and 5 YR ¾, 2067 mg kg-1 Ca, 271 mg kg-1 K, 168 mg kg-1 Mg, 238 mg kg-1 P, 14.0 mg kg-1 Zn, 2.6% OM

in prime *dűlő*-s for several generations reported identifying the *Király Dűlő* in another producer's dry wine because it had the same flavors as her own wine made from *Király* grapes. In this case, the common denominator was the *dűlő*, and its influence was tasted above any other.

VI. DISTINCTION, DECODED

a. Wine from a stone: "The M Word"

In his book, *Volcanic Wines: Salt, Grit, and Power*, Master Sommelier John Szabo (a Canadian of Hungarian descent) traces a winding map of plate tectonics, exploring wines that originate at their interface. Explaining the continuity of his work, he argues that "wines from volcanic soils hinge on a common mouthwatering quality, sometimes from high acids, almost always from palpable saltiness, sometimes both" as well as savory notes, "non-fruity flavors in the earthy and herbal spectrums of flavor, along with all of the nuances covered under the magnificently useful, multi-dimensional term *minerality* and all of its varied definitions. Minerality and volcanic wines walk hand-in-hand." (2013:14).

Perhaps no other word in wine production is so simultaneously beloved and maligned as *minerality*. This term—in Hungarian, *mineralitás*, or *ásványi*—has become ubiquitous in wine circles since it first appeared about thirty years ago. It suggests tastes and aromas that do not fit the herb/spice/fruit spectrum of flavors, registering near the back of the hard palate (FIGURE 35). Sensory evaluation researchers Rodrigues et al. (2015) examined *minerality* in wines as socially-represented in varied ways across two groups of French producers and consumers, suggesting that, while the concept is not "stable", it has a uniting *positive* connotation across both groups, "which results in a sensory descriptor denoting quality" (166).

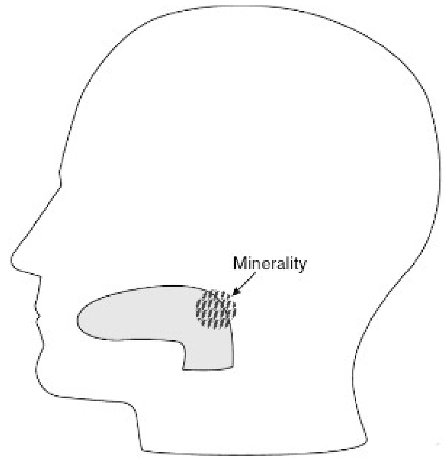

FIGURE 35: Locating the sensation of minerality (Smith 2013:105)

Minerality as a descriptor is absent in wine texts prior the year 2000, yet today's popular titles, such as *Decanter* magazine, feature minerality and its derivative words easily over 100 times within a single article (e.g. Decanter, July 2012:76-83, cited in Maltman 2013). The word appears to have a certain usefulness, if not trendiness, despite lack of consensus as to how minerality is defined or sensed, being absent from most contemporary standardized tasting schemes and aroma wheels (Maltman 2013:170, citing Jackson 209, Noble et al. 1987, Pickering and Demiglio 2008, and Gawel et al. 2000). Perhaps currently at (or, for some, past) its peak, *minerality* is the hallmark of quality white wines—a dividing line that separates outstanding wines from their average counterparts. Today, influential wine writers are shying away from the word, considering it too vague, its use too imprecise, and its meaning lacking in consensus among wine tasters and scientists alike. Bence, a Hungarian wine writer, has followed this decline; he tells me with a touch of sarcasm that he will try to be *correct* and use words like "*struck flint*" or "*wet stone*" instead.

Amid the controversy are experts in soils and geology, each with their own take on minerality and *terroir*, ranging from impassioned to amused. Alex Maltman, a Geologist at

Aberytwyth University in Wales, published his perspective in the Journal of Wine Research (2013). Puzzled by this escalation of the use of minerality (despite any common definition or empirical evidence), he notes (170):

> It seems self-evident that the terms normally used to describe wine-tasting sensations are metaphorical… No one thinks that a wine perceived as smelling of, say, tropical fruits of new-mown hay, or tasting of spice or leather has actually involved those materials in its production. But minerality is different.

He supposes this is a romanticizing of provenance, guided by today's common knowledge that wine—like all foodstuffs—does indeed contain trace minerals (albeit not perceivable to human taste). Maltman also supposes that, because modern wine tasters know plants require *minerals* (ionic nutrients) to thrive, it is almost as if "some still view vines as being largely made from minerals in the ground, a legacy from before the discovery of photosynthesis" (170). He concludes that any perception of minerality in a wine must not be a literal, direct one, but "complex and circuitous" (170). This is further complicated by fermentation, which removes many nutrients (namely, zinc, copper, and barium) and adds others (aluminum, calcium, iron) (Castinera et al. 2004 in Maltman 2013), not to mention the effects of filtration, barreling, bottling, etc.

Maltman's article and subsequent presentation at a convention of wine professionals no doubt left an impression on Jancis Robinson, perhaps the most respected wine critic in the world, who in October 2016 wrote that:

> …a bearded geologist from the University of Aberstwyth in Wales robbed 58 Masters of Wine, MW students, and fellow wine lovers of one of their favourite concepts…. [illustrating that] there can be no direct link between what is below the surface of a vineyard and the flavours found in the resulting wine. (2016a)

Summarizing the talk by “bearded” Maltman, Robinson boiled the confusion over “the M word” down to ambiguous terminology: *nutrient elements* versus geological, mostly insoluble *mineral compounds*. While 14 nutrients are taken up by the plant itself to thrive, these are found *not* by reaching deep into bedrock (as is common folklore), but in the upper, solum layer, up to a depth of about .5m (Keller 2010). Only groundwater may be accessed at lower depths (typically up to 2m). Like other crops, grapevines require a suite of nutrients (including N, P, K, Mg, Fe), and many landscapes have an overabundance of one or more—but often only a fraction of this is bio-available to the plant. In the end, the vine itself is the regulator, taking up only what it needs. Inorganic minerals comprise only about 0.2% of wine, according to Maltman: “I’m not saying minerals and geology are not important—just that you can’t taste them directly.” He adds the caveat that, “it’s always possible that science is missing something” (Maltman in Robinson 2016)—a possibility that leaves fertile ground for speculations on minerality and the *literal* role of place in the tastes of PDO foodstuffs. For many, the translation of provenance into irreproducible *experiences* is evidence enough.

b. Translating *terroir*

Back in Budapest in December 2016, I participated in a wine tasting and presentation: “*Terroir* wines of Hungary”. The classroom was a stark, modern, white and grey minimalist space with a semi-circle of Ikea desk tables laid out with a repeating pattern of wine glasses, reading materials, pamphlets, and the wine list for the evening with room for personal notes. In the front of the classroom was a large paper drawing pad and another desk for the speaker to use. The presenter was Panni, a young Hungarian woman with international wine teaching and judging experience, a series of certifications, and a passion for *terroir* wines. She began:

> In Hungary, we lucky enough to be blessed with an extremely diversified soil structure and diverse areas of production. And all these are concentrated in a small area, so we can taste many kinds! I think, if you go to Tokaj, you can almost differentiate individual *dűlő*-s based on tastes, which for now we are unsure how to [explain], but we think that it is *some* kind of *terroir*.

The remainder of the taste-lecture included hand-drawn sketches of vine-in-soil profiles, maps, and tips on recognizing various environmental variables in the tastes of the wines. Most basically, this came in the form of recognizing minerality in wines and feeling the "structure" of the *dűlő* soils through experiencing the wine itself. Throughout the program, Panni acknowledged the lack of scientific consensus regarding this connection, but maintained a firm belief in the physical presence of soil characteristics in the final product:

> The soil is dissolved by water […] and the grapevine can absorb the molecules of the soil. So in some way it *must* get in through the root. In the end, if it appears in fruit or not, it is difficult to say. But it *is* in the grapevine and, with the nutrients, it gets to the fruit. So this can't be denied. Obviously, there is interaction between soil and grapevine. Obviously what *type* of molecule that is, if it's volcanic or a limestone molecule or clay, it doesn't matter—it is important *in* the plant. [Researchers] say it does matter what type of structure of soil there is…. Because molecules get in the plant that reflect the *terroir* in the wine.

She further explained that there are many soil types in Tokaj, some volcanic and others not—including limestone-rich, loess soils, "but it is *still* mineral—we can taste mineral flavors. So they get there somehow." Another wine seller in Budapest, a young man in his 30s who worked previously in a high-end restaurant, recounted in a preliminary interview, "The soil of Tokaj is full of minerals, and you can taste it in the wine. If you just *smell* a bottle of Tokaji, you can tell it's a Tokaji."

The expertise of wine researchers, chemists, and the like is negotiated by producers and wine professionals with experiential and local knowledge. Wine expert Panni discussed this tension between Hungarian producers and geoscience expertise in her presentation of *terroir* wines:

> …some say that these [soil] elements can't actually be found in wine—what chemical particles are present or not, based on the soil type…. So, actually, this research says that we *can't taste* in a wine if it is limestone or volcanic. Me, I don't agree, because I think it is possible to differentiate between these two. But obviously my opinion doesn't count.

Her opinion is not unusual: at the annual "Tokaj Grand Tasting" event in Budapest (March 2017), the main ballroom was a visualization of the primacy of minerality and volcanic-versus-limestone origin. Laid out, as if a trade expo, were rows of tables with poster boards, bottles, glasses, and ambassadors from each winery—and on over 50% of the tables were minerals on display: evidence of volcanic *dűlő*-s. Those who championed the non-volcanic, loess aspect of Tokaji *dűlő*-s did not miss the opportunity to display a profile of their ash-like soil in a clear, glass cylinder (FIGURE 36, right).

FIGURE 36: Volcanic (left) and loess (right) wines represented at the Grand Tokaj Tasting, March 2017

Claude Bourguinon, a French agronomist who has left academia to set up his own private laboratory and "embrace a broader view of viticulture and geology" (Patterson et al. 2017:82) has recently defended his position that the soil contents are, indeed, reflected in their wines. Bourguinon gives a brief overview of recent findings in his research in Burgundy, which include "a distinct correlation between types of clay and a wine's colour," noting that "by means of science and agronomy [they] were also able to confirm that the 1936 tastings leading to the Bourgogne crus classification had got it right." In light of these findings, he concludes that "scientific tests and subjective tastings are *complementary tools*" (Bourguinon in Patterson et al. 2017:84, emphasis added). Certainly any transfer of soil qualities to end-product must be thanks to the work of the *vine* itself, a factor that many producers touched on during my time in Tokaj.

c. The work of grapes

Vitis vinifera, the Eurasian grape, is the single species from which nearly all wine consumed today originates. An estimated 5,000-8,000 unique cultivars of vinifera exist today, the product of millennia of domestication since circa 7,000ya. The plasticity of *V. vinifera* makes it highly adaptable, as one wine and hospitality expert described to me in Budapest, it is a “promiscuous weed”. This weed, domesticated and trained along trellises, is the agent through which *terroir* qualities are ostensibly transferred into the juice itself.

In Tokaj, six varietals are legally produced under the PDO scheme (five of which are native), but one variety dominates every hillside. This varietal is highlighted in one tourist brochure: between two glossy, picturesque covers, over a dozen of the region’s most prominent wine makers were showcased, each of them describing their connection to Tokaj *terroir* and a specific grape varietal thought to best-exemplify the local *terroir*: *Furmint*.

Furmint is indigenous to the region, first mentioned in 1571 in the Hétszőlő *dűlő* of the Tokaj village area. It is a progeny of Gouais blanc and a second, yet unknown parent, making it the “half-sibling” of Chardonnay, Riesling, and other well-established white grapes; it is also the likely parent of other indigenous varietals (including *Hárslevelű*, or Linden Leaf). Today it is the most common varietal grown in Tokaj, even more so in Hamvas, where it covers over 70% of vineyard area. Thus, essential to the transfer of *dűlő* qualities to the end-product is the vine, accompanied by minimal human intervention: producers use as few chemical additives as possible, resorting to pesticide only if absolutely needed (if at all), and very rarely using any sort of inorganic fertilizer. András, for example, believes that this would be a step backward, since Tokaj producers “have only one possibility to be a brand in the future: to show the kind of soils in the wine. If you add fertilizer, or anything, it covers up. It’s not authentic.”

Furmint has always been the favorite of Tokaji producers, even during the heyday of sweet wine production, because it is a good host for the botrytis fungus (a beneficial form of *Botrytis cinerea*) that characterizes its famous aszu wines. The Tokaji Album of 1867 considers Furmint (and its "varieties", hólyagos, világos, madarkás, etc.[19]) to be the top in a select group of four grapes that "furnish the noblest dry berries (*aszú szemeket*) for the Tokaji aszu" (62-63). Today, it is Furmint's ability to reflect its environment in the wines, "unveiled" in the production of dry wines (rather than sweet, botrytis-affected wines) that makes it conveniently fit for Tokaj production. Dry wines, producers and wine experts alike are quick to say, are better suited for expressing the *terroir*, as the sweetness can cover up those delicate qualities.

András explains the overwhelming popularity of Furmint in his own *dűlő*-s:

> The other three [top varietals] have much less taste. So [Furmint] is good in sweetness, good in botrytis, but good *taste*. And we can focus on the foreign market prices…. In order to communicate abroad, we can really use only one grape variety. And we have to choose one. But there was no question, because 75% is [already] Furmint.

András's decision to go with Furmint "no matter what" is at the nexus of *terroir* rationale (that minerality is transcribed by the vine into the product) and a historic inertia based an older iteration of *terroir* rationale (that botrytis needs a good host berry—thin-skinned and high in acid), coupled with a global disinterest in "sweet wines" and the now-dominate dry wine market; all of these factors have led to a region increasingly dominated by one versatile varietal.

Bourguinon has suggested an even more literal relationship between vines and their soils, as Master of Wine Anthony Hanson writes on soil genesis (1995:74):

[19] By most definitions used today, Furmint is one varietal (a spontaneous crossing of Gouais blanc with a second varietal), and the "varieties" of Furmint described in the album are probably clones with color or other phenotypic mutations.

A future line of research is to quantify the proportion of soil that is vegetal, rather than mother rock, origins of Burgundy's vineyards. Old root cells from buried, decayed vines may make up 70% of some soils, so recent scannings by Claude Bourguignon suggest. So six centuries of monoculture—or more—could prove to be the real creators of these soils.

Bourguinon seems to be suggesting as high as 70% organic matter in some of Burgundy's soils, a figure that far outstretches conventional wisdom and advice in viticulture, which posits 3-6% organic matter as ideal (e.g. Goldspink 1997).

d. Suffer or perish

"*The vine must suffer*" is a common expression among wine growers, including Janos, who says the best areas are where the vines are not *too* strong and the fruit is very tasty. He finds that these *dűlő*-s are without "too much clay on the surface," because "this [soil] is too rich, contains too much nitrogen, organic material, and because of this, the fruit loses some taste and aroma."

Because *V. vinifera* evolved and was domesticated in Eurasian, calcium-rich soils, perhaps the nutrient-poor, volcanic soils of Hamvas *do* provide just the right amount of "suffering" required to concentrate its efforts in smaller, "quality-over-quantity" bunches. This tension between quantity and quality is played-out on the material landscape of Tokaji vineyards. Grapevines in Tokaj, many having outlived their human counterparts throughout the last century, have very directly experienced the repercussions of changing regimes. During soil sampling, I asked András why many of the older plants were in disproportionately wide rows. He explained:

András: Yeah, that's from the communist time. Now you can see what we planted there, and this one—so two meters is the norm today.

> Author: Do you think it's better quality, like this? To be closer? Or does it make a big difference?
>
> András: Not *only*—it gives better quality because of the smaller distance. But it's because of the sun and many other things…. More leaves, smaller size, smaller bunches…. [Their] behavior is different.

Because management practices during communism widened rows and thus changed "grape behavior", the legacy of socialist-era practices may even override even the innate qualities of the *dűlő*-s themselves. This is because grape vines are understood to become better *terroir* transmitters with time—additionally, the slope itself . András agrees: "at 10 years old, or at 40, or 100 years old, plants can bring different volumes of minerals into the bunches". In one exemplary case, András pointed out a white house with an adjacent parcel of land:

> I think this is the best slope of the region. It's called Szarvas [Deer]. But today [that assessment] is not 100% right, because it's owned by the government. And they cut all the old plants, so it's 100% new plantings, so no old vines there.… So the Hungarian—the government's own—company is not interested in the old [18th century] classification, because they are working with *cheap* wine. There is no point in using the classification.

In the case of this *dűlő*, which is simultaneously "the best" and also "not 100%" the best, the role of its owner (a holdover from communism) has tempered its natural potential, a slope described by András as "one of the warmest slopes in the region" with fine, loess soils that cover the vines like a thick blanket. The vines, which were old (ideal *terroir* transmitters), were removed and replaced with new ones by a regime that failed to recognize distinction.

With this introduction of human agency, it is impossible not to reconsider Bourguinon's notion that that vineyard soils are (at least to some degree) anthropogenic—shaped by the continuous monoculture of wine-making over centuries. This idea is itself a clear illustration of the co-production of minerality as it emerges at the nexus of ideology, human action, and the material landscape. Although, in our analyses of samples collected for this project, vineyard soils of Hamvas and Tokaj averaged 2.0% and 1.9% organic matter, respectively (much lower than Bourguinon suggests above), the exceptionally and surprisingly nutrient-rich soils of Hamvasi vineyards may be clues to their own past. Their high rates of phosphorous (averaging 136.2 mg kg-1)—despite their volcanic, acidic, typically nutrient-poor status—is actually typical of intensive agricultural sites (Deiss et al. 2017): the literal minerality of Hamvasi soils may in fact reflect the legacy of previous over-fertilizations.

e. Fragmented geographies

Producers in other villages outside of Hamvas recognize the work of the Hamvas Roundtable, and respect the basis of their arguments. Dáni, a man in his mid-30s operating a small family production and guesthouse in the village of Érdőbénye, explains his views on their ground-up approach to regulation:

> Hamvas and every single village have their own mineral type, soil type, microclimate. Not only the villages but also the 8-9 *dűlő*-s of each village can have different microclimates, and within a single *dűlő* the lower, middle and higher area can have different soil structure, and this leads to such a magical diversity.

Naturally, it is not enough that a village be different—it must be *distinct*. In representing place-brands to a global market, appellation initiatives cannot always account for the diversity of the 27 villages of Tokaj, but instead rely on simplification and broad strokes: *volcanic* top soils versus calcium-rich *loess*. András went on to explain the potential of each soil type, with a critical attention to the importance of volcanic *minerality* to an international audience:

> …loess also makes age-able, good wines, but in wine-drinking *culture*, if you see Hungarian [wines] abroad, it's— [he pauses].
>
> The loess can make a very *elegant* wine. But today, the brand is improving as we make a much more full-bodied wine. And if you present two wines, one from loess and one from rhyolite or andesite, the second one is always the winner. *Always*.

Andras's arguments echo broader trends in wine, discussed below, where minerality serves as the marker of distinction and superiority; in this way, it reinforces the quality of Hamvas village soils in contemporary terms but separates its distinctive quality markers from any used historically to define the Tokaj brand. With their own labeling scheme, Hamvas producers are expunging baggage of the Tokaj name and its complicated history—a gamble that seems to be paying off for producers in the Hamvas Roundtable.

Yuson Jung's paper on "unknown *terroir*" and Bulgarian wines (2014) reveals striking parallels: in a marginal place of production, earning a place among the world's elite wines means presenting *terroir* wines with distinctive minerality, a quality that one British wine judge failed to detect in any of the 20 Bulgarian wines he judged at competition. Like Hungarian producers I spoke with, Jung's key informant, a veteran producer, insisted that quality comes from rocky *terroirs*: "fine wine comes from grapes that struggle, like in the midst of gravels and rocks—fine wine doesn't come from rich soil" (33). As the British wine critique was unable to recognize any *terroir*—unable to decipher any of the "taste of place" required for "fine" wines—Jung is led to ask, "how do marginal winemakers present the taste of an unknown ground?" (33).

Perhaps one answer to this is an exercise in translation: grounding sensory experiences in volcanic origin stories. In John Szabo's book on Volcanic Wines, Hungary is one of eight regional-divided chapters, where he outlines with great expectations the present state of Tokaj's "post-volcanic, post-communist era" (238). In doing so, the volcanic wines of Tokaj are in a special minority of increasingly sought-after wines, bestowed upon them by a material, indiscriminate *terroir*. Claude Bourguinon, the French agronomist taking up the often-discarded soil-based questions of *terroir*, explains:

> Our planet has three types of rock: 90% metamorphic, 3% volcanic, and 7% limestone. The vine, originally found growing in Caucasian limestone, is a plant that thrives in lime-rich soils…. As for the great whites, the wines of Alsace, Moselle and Anjou need metamorphic rock and Hungary's Tokays [sic] require volcanic rock…. Wine-makers have to accept the unfair fact that *terroir* is undemocratic and that not everyone is lucky enough to have it. (Bourguinon in Patterson et al. 2017:84)

The "luck" of having *terroir* may not be fair or democratic, but a step toward making quality *terroir* wines in Tokaj is a step forward, away from an even less-enticing mode of production.

"In some parts, the Tokaj region is still communist," András explains, as we approach a quarry, where he wants to show me a cross-section of a local hill. I ask him to clarify, "Because of the way that it is organized and the way it is managed—it's very communist, you mean?" He replies, "Yes. And in mind…. They don't believe in quality, *still*. They cannot *feel* the differences. They say it's only a fashion. It's not a *real* thing. Can you pass me the soil knife?" he concludes, as he carves some rhyolite from a cliff face and hands it to me (FIGURE 37).

FIGURE 37: András punctuates his point with an exhibit from an abandoned mining site.

VII. MINERALITY MATTERS

a. “Lifting the veil” in Tokaj since 1730

The living and non-living *terroir* constituents in Tokaj operate within a structure that is highly regulated, not only by producers, but by legal apparatuses—this has been the case since the original 18^{th} century classification system. In Tokaj, the sequential changes in governance that occurred over the last 100 years have literally altered viticultural ecosystems—and thus, the *terroirs*—of its historic *dűlő*-s. Producers acknowledge these alterations, which today are visual reminders of political legacies, rendered in the vineyards themselves.

In short, the legacy of several centuries of political turmoil, scientific expertise, and sense experience in Tokaj has been transcribed into the material *terroir* itself, even as the materiality of *terroir* informs scientific questions and sense experiences (if in “as yet” immeasurable ways). A turn to a more place-based model of quality is readily accessible, a “geological trump card” of quality (Josling 2006), means using objective studies and scientific expertise to frame regional qualities as innate, immutable, and thus available to experience (rather than the product of a very fragmented account of generational knowledge and local expertise). *Terroir* is an origin story—co-produced by scientific study and sense experience, where sense experiences inform the very questions posed by scientists. To echo Jasanoff, a review of *terroir* and origin schemes must ask "What kind of science for what kind of world?"

"Scientists, you would not believe how many of the most basic questions about wine remain unanswered," Jancis Robinson said in 2015 to a class of science graduates. While a surprising number of seemingly foundational questions in wine production remain unanswered, research requires funding, and contemporary viticultural research seems to be less interested in "the M word" and focuses instead on more pressing matters: production technology, climate change, grape genetics and diseases, to name a few. Many in Tokaj (and indeed, worldwide) take this in stride, resting in the knowledge that innovative, scientific "unveilings" of *terroir* qualities come with each passing generation. It was only in 1860 that Louis Pasteur understood yeast to be the cause of fermentation, and yet, "not knowing how grape juice became wine didn't stop it from doing so. And not knowing how what we identify or describe as 'mineral' gets into wine doesn't mean it isn't there, it just means we have yet to learn." (Bibendium 2015).

As another wine writer comments in the forward to *The Dirty Guide to Wine*, "…even if the scientists and the technical wine people tell us it isn't so, that doesn't mean that a sense of place doesn't get delivered and that dirt and soil don't have a part in it. Even if no one really yet understands 'how' this can happen" (Feiring and Lepeltier 2017:17).

b. Minerality and *terroir* as co-constructs

In Tokaj, the expertise of the environmental sciences is used not only to make decisions (in-situ) but in order to interpret, translate, and serve as representations of the place itself to outsiders. The *presence* of rhyolite, for example, does not prompt producers to alter their practices, rather, the rhyolite tuff itself is presented alongside the wine as harbinger of excellence, as an evidential "ecofact" and sign of unique quality, even as some intentionally add the material to their new plantings. These signifiers are the much less ephemeral counterparts to the human (and even climate) aspects of *terroir*, justifying the perseverance and survival of one of the world's oldest wine regions in a time of European overproduction (known as the "wine lake").

A move toward quality—toward *minerality*—is also a step away from a quantity-oriented communist past. Simultaneously, it re-orients the value of different agricultural landscapes: where Nitrogen-rich loess deposits once provided the warmth and nutrition required for an abundance of sweet wines, a shift toward lower quantities has dramatically increased the appeal of volcanic soils with moderate nutrient content and lower pH. In this way, the post-1989 transition also redistributes a type of power along geologic lines in an "undemocratic" fashion (Bourguinon in Patterson et al. 2017:84).

Terroir and its governance is thus an ecologically social project that recruits every participant within the *terroir* network, including the grapevines themselves, to produce the taste of place. Grapes are indicators with biological needs and "preferences"; they communicate their happiness—or frustrations—in their product. Grapes know what they like, and if good wine is an indication of contentment, they have a strong dislike for communist production.

The resulting material soilscape is equally co-produced. As it is often written in ag extension materials, the only way to know what "ideal" viticultural soils are is to plant and produce wine—then decide (e.g. Chien 2012). Moreover, the "ideal" parameters described by extension materials are almost never present in natural conditions; a seeming contradiction for those looking to present a direct link to an unadulterated "place" through PDO wines. Viticultural soils in Tokaj, where a monoculture of V. vinifera has shaped the hillsides for centuries, are in a sense *anthropogenic*, the soils themselves artifacts of political interventions, reversing production aims (which are reflections of market demands and consumer tastes), and the monocultural cultivation of a long-lived, perennial "weed".

Through a co-productionist lens, we can begin account for *terroir* in a holistic way: the embeddedness of cultural factors (e.g. *what counts as 'quality'*) driving research questions in Hamvas/Tokaj (e.g., *identifying terroirs*), while at the same time illustrating how ideologies and politics (e.g. *PDO labels, communist legacies, global market*) materialize in agro-ecologies (e.g. *soil quality, varietals planted*). Expertise becomes a currency in a market increasingly interested in "knowing where its food comes from" and increasingly taking to heart the expression, "you are what you eat". Volcanic minerality becomes the signifier that emerges from this rhizome of techno-scientific, socio-cultural, and material confluences. Thus, *terroir* and its primary signifier, *minerality*, are co-produced through epistemes and material agents, living and non-living, many of which are almost personified by scientific language in the identification of their locale and "fingerprinting" of their identities, political boundaries and social histories reflected in their very biology.

c. Conclusions

This chapter suggests that, because regional traditions and viticultural methodologies are disputed in post-socialist Tokaj, the value of a *dűlő* is most reliably and convincingly interpreted by producers—and translated for consumers—through the most static of factors: geology and, to a lesser degree, climate. Producers rely on the expertise of environmental science primarily as an *explanatory* narrative that clarifies and confirms the intrinsic quality and established history of a particular site, already known to be unique to locals through centuries of observation and experience. In this way, the construction of *terroir* in *dűlő*-s is a socio-ecological process at the confluence of culture, politics, and vineyard ecologies.

Further, because producers are banking on *terroir* as the uniqueness that will catapult Tokaj onto the global scene, they are increasingly turning to one indigenous varietal thought to best showcase the qualities of its *dűlő*: *Furmint*. While this grape has always played a significant role in the region, it now covers over 60% of planted vineyards, leaving the other 5 permissible varietals to share the remaining smaller share. The allure of *terroir*, whether quantifiable, mappable, or otherwise traceable, *is* marketable—and this is visible in the decision-making of producers in contemporary Tokaj, many of whom see *dűlő*-based production as the way forward.

Political regimes have altered viticultural systems in historic Tokaj, but they have also shifted the greater wine world. Debates around the "true" and "authentic" way to make Tokaji wines remain heated, particularly as they are codified and protected through PDO labels. Meanwhile, looking to the recreate the past is not a sustainable solution, as demand for its trademark sweet wines has waned (due to global demands, perhaps linked to the purported health benefits associated with the consumption of dry red wines). Thus, politics, scientific knowledge, and agro-ecology ought not be considered separate spheres of inquiry, but rather—like *terroir* itself—considered within a network of co-produced relationships. Further, political tools of governance—such as the PDO label—themselves become part of ecosystems as the humans that create and enact them.

Today, as historically, expert knowledge is wielded politically as a tool in the Tokaj region to make absolute claims about very subjective and temporal outcomes (tastes, quality). Lay knowledge complements this expertise, and producers—who depend on drinkable wine for their livelihoods—act rationally based on this information. At the same time, producers discuss soils and grape varietals as their co-conspirators rather than objects of their intention, admitting their own vulnerability and assigning non-human agency to various points in the system, especially to grapes and the botrytis fungus that yields the traditional sweet wines (and does *not* come every year). *Dűlő*-s, as agroecological systems, are also discussed as characters, with their own contributions to and fingerprints on their products.

While communist-era production was about using expertise and mechanical innovation to maximize efficiency in terms of output, post-communist winemaking in places like Hamvas appeals to expertise to maximize *terroir expression* (efficiency in quality, so-to-speak). This means understanding indigenous grape varietals, understanding the indigenous yeasts and other microbial helpers, and—perhaps above all—knowing the soils. In this way, Tokaji *terroir* is translated from the ground up using a scientific narrative, language that reads as objective and rational. *Terroir* in Tokaj—indeed, across the globe—remains a point of debate with political and ecological implications, an evolving network of human and non-human participants engaged in a centuries-old project of distinction.

CHAPTER 4

CONCLUSIONS

This thesis, in its two-fold purpose, set out to characterize two sub-zones of a historic wine region in Northeastern Hungary after decades of political (and coinciding) environmental change. Because the concept of *terroir* assumes a distinct connection between "local" foods and their places of origin, it provided an ideal starting point for analyzing the connections between people, politics, and place. With a background in the social sciences, and the scientific literacy afforded by the Masters program in Crop and Soil Sciences, connections between people and place were drawn using both scientific methodology (soil testing, statistical analyses) and ethnography (discursive/interview data, participant observation).

Using a participatory method, which coupled well with the research question, not only allowed for a more thorough investigation of *terroir* production in this region but provided soils data that would have otherwise not been collected; this included vineyard subzones, which allowed for the accounting of in-site heterogeneity (not only between the two villages). This paralleled a common narrative among producers on the ground: high levels of variation and soil heterogeneity characterized their (often 'best") vineyards. As presented in the two examples above (from *DŰLŐ A* and *DŰLŐ H*), variation within vineyards is high. While soil types did not necessarily change within these zones, the visual cues followed by producers did lead to (sometimes drastically) different zones of production. Although in both cases producers reported adding no fertilizers, any amendments or recommendations for these soils would benefit from this higher-resolution account of variability, particularly as these sites may have been over-fertilized in the past (judging from high rates of P found in Hamvas sites).

Of course, these results do not point to (nor were they intended to illustrate) a definitive marker or causal explanation of *terroir*; rather, it illustrates the material differences between (and within) two villages within one small wine region, quantifiable in terms of available nutrients and pH. Considering the flexibility of current PDO regulations in the region (anything sweet, dry, or sparkling made with the six approved varietals and grown within the borders of the region may be labeled and sold as Tokaji), and the lack of standardization in methodology across the region, the results of the soil analyses present a landscape that is also materially fragmented, without the homogenous growing conditions that are often assumed for a given PDO (especially in winegrowing, where geographically-anchored labels presuppose a certain amount of regional homogeneity).

In light of these findings, the question of policy and border-defining in the PDO scheme (and other Geographical Indications) is further complicated; at its core a political border, the use of science in reifying or clarifying those borders is an area well-deserving of further research, particularly in contested areas such as those in the Tokaj region. Further, the connections between these material places and the affective appreciation of their products is as tenuous as ever and attempts to objectify and quantify those connections are certainly rich areas of interest for scholars of science and technology studies or the history and philosophy of science.

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SAMPLE ID	pH (CaCl2)	Ca (mg kg-1)	K (mg kg-1)	Mg (mg kg-1)	Mn (mg kg-1)	P (mg kg-1)	Zn (mg kg-1)	SS (mmhos/cm)	% OM	Dűlő
TK1	7.8	3619	86.4	227.4	43.64	137.6	12.01	0.15	2.42	A
TK2	8.1	3968	48	214.1	27.07	62.8	9.11	0.16	2.04	
TK3	7.5	3915	168.8	435.8	63.28	125.4	20.89	0.14	2.55	
TK4	7	2307	52.9	248	23.5	54.4	6.06	0.09	1.9	
TK5	7.7	2761	50.7	212.4	24.34	119.2	5.91	0.09	1.7	
TK6	7.9	2253	36.9	177.1	12.68	115.1	3.87	0.12	1.04	
TK7	7.9	3310	73.6	220.3	26.84	86.6	4.77	0.16	2.47	
TK8	7.9	2819	41	238	9.35	73.9	3.48	0.1	1.46	
TK9	8.4	5813	32.8	189.4	2.3	2.8	0.05	0.18	2.66	
TK10	8.6	6578	24.9	220.4	1.14	2	0.04	0.16	1	
TK11	8.4	6144	120.7	306.4	23.22	9.3	1.17	0.15	1.62	B
TK12	8.5	4818	32.8	585.5	25.86	8.3	1.19	0.17	1.1	
TK13	8.3	2137	47.9	305.2	40.02	108.9	1.12	1.12	0.93	
TK14	8.4	5482	136	289	7.93	5.7	0.06	0.27	2.41	C
TK15	8.4	6053	38.4	232.7	8.97	4.1	0.14	0.35	1.95	
TK16	8.5	6067	51.7	251.5	6.68	4.7	0.07	0.19	2.07	
TK17	8.3	6377	34.5	272.2	11.27	11.7	0.63	0.18	1.8	
TK18	8.5	5882	111.8	297.4	8.05	8.8	0.05	0.23	2.12	
TK19	8.4	5966	34.4	307.1	3.95	4.5	0.06	0.18	1.44	
TK20	8.6	6023	43.1	395.1	4.85	4.1	0.06	0.17	2.03	
TK21	8.6	6172	25.1	551.7	1.33	1.8	0.04	0.19	1.24	
TK22	8.6	6980	28.1	313.7	7.74	1.7	0.03	0.25	2.1	D
TK23	8.5	6009	26.1	217.6	2.34	3.1	0.03	0.19	1.75	
TK24	8.5	5854	99.9	227	12.93	13.9	0.05	0.33	2.8	E
TK25	8.3	6127	57.3	245.5	2.11	14.6	0.14	0.25	2.82	
HV1	7.4	3280	239.7	243.9	46.12	162.9	12.74	0.27	3.36	F
HV2	7.2	2407	366.5	211.8	55.07	205.8	21.51	0.11	3.54	
HV3	6.5	1561	184.2	168.6	47.72	103.5	11.41	0.19	2.41	G
HV4	7.4	2574	359.3	167.7	53.68	372	15.91	0.1	2.8	
HV5	6.1	498	95.6	32.4	27.45	98.2	5.14	0.09	0.99	H
HV6	6	316	65.3	20.2	11.21	74	13	0.08	1.37	
HV7	5.4	265	74.2	29.9	43.21	38.8	6.52	0.04	0.93	
HV8	5.3	277	73.6	29.8	42.51	34.4	19.39	0.04	0.87	
HV9	8.4	6702	110	690.8	3.93	4.8	0.13	0.25	1.76	Mine Dust

Appendix 1: Soil testing, raw data: pH, Mehlich, soluble salinity, and organic matter

Sample ID	Munsell Color	Dűlő
TK1	10YR 4/3	A
TK2	10YR 4/3	
TK3	10YR 3/3	
TK4	10YR 3/3	
TK5	2.5Y 4/4	
TK6	2.5Y 4/4	
TK7	7.5YR 2.5/3	
TK8	10YR 4/6	
TK9	2.5Y 4/3	
TK10	2.5Y 6/4	
TK11	2.5Y 4/3	B
TK12	2.5Y 4/3	
TK13	7.5YR 5/3; Inclusions: 2/5Y, 2.5/1, 10R 4/6	
TK14	10YR 3/3	C
TK15	10YR 4/3	
TK16	2.5Y 4/3	
TK17	10YR 3/3	
TK18	2.5Y 4/3	
TK19	2.5Y 4/3	
TK20	10YR 4/3	
TK21	2.5Y 4/3	
TK22	2.5Y 4/3	D
TK23	2.5Y 4/3	
TK24	10YR 3/3	E
TK25	10YR 3/3	
HV1	5YR 4/4	F
HV2	10YR 3/6	
HV3	5YR 5/4	G
HV4	5YR 3/4	
HV5	10YR 5/2	H
HV6	7.5YR 5/3	
HV7	7.5YR 4/3	
HV8	7.5YR 4/2	
HV9	2.5Y 8/3	Mine Dust

Appendix 2: Munsell color codes, raw data