Of soil, yeast, and petrol: Groundbreaking studies of Riesling's multifarious delights

Anne Krebiehl reports on the pioneering work of German wine scientist Dr Ulrich Fischer, who presented his latest findings on terroir, yeast, and the development of petrol aromas in Riesling to the wine trade in London in December, shedding new and fascinating light on the great white grape variety's capacity to reflect its origins and evolve over time

So-called creationists may balk at science, but those of us who find our awe of nature's infinite ways enhanced by true understanding will welcome every new insight that helps us explain the seemingly inexplicable—especially when it is such a delicious but mind-boggling subject as the shimmering, multifarious, and often tantalizing peacock's tail that is the aromatic expression of Riesling.

On December 4, 2013, before the inaugural meeting of the Riesling Fellowship—a new initiative of the German Wine Institute in cooperation with the German Embassy in London, to honor champions of Riesling in the UK—an audience of wine professionals was treated to the latest academic findings on three Riesling-centric issues at the Vintners' Hall. German wine luminary Professor Dr Ulrich Fischer, head of the department of viticulture and enology at the Rheinland-Pfalz state wine research center in Neustadt, Germany, shared his team's research on "The Sensory Finger Print of Terroir in German Riesling," the "Terroir of Yeast: Signatures of Spontaneous Fermentations," and, perhaps most intriguingly for Riesling lovers, the aroma compound "formerly known as petrol."

A few thoughts on Riesling

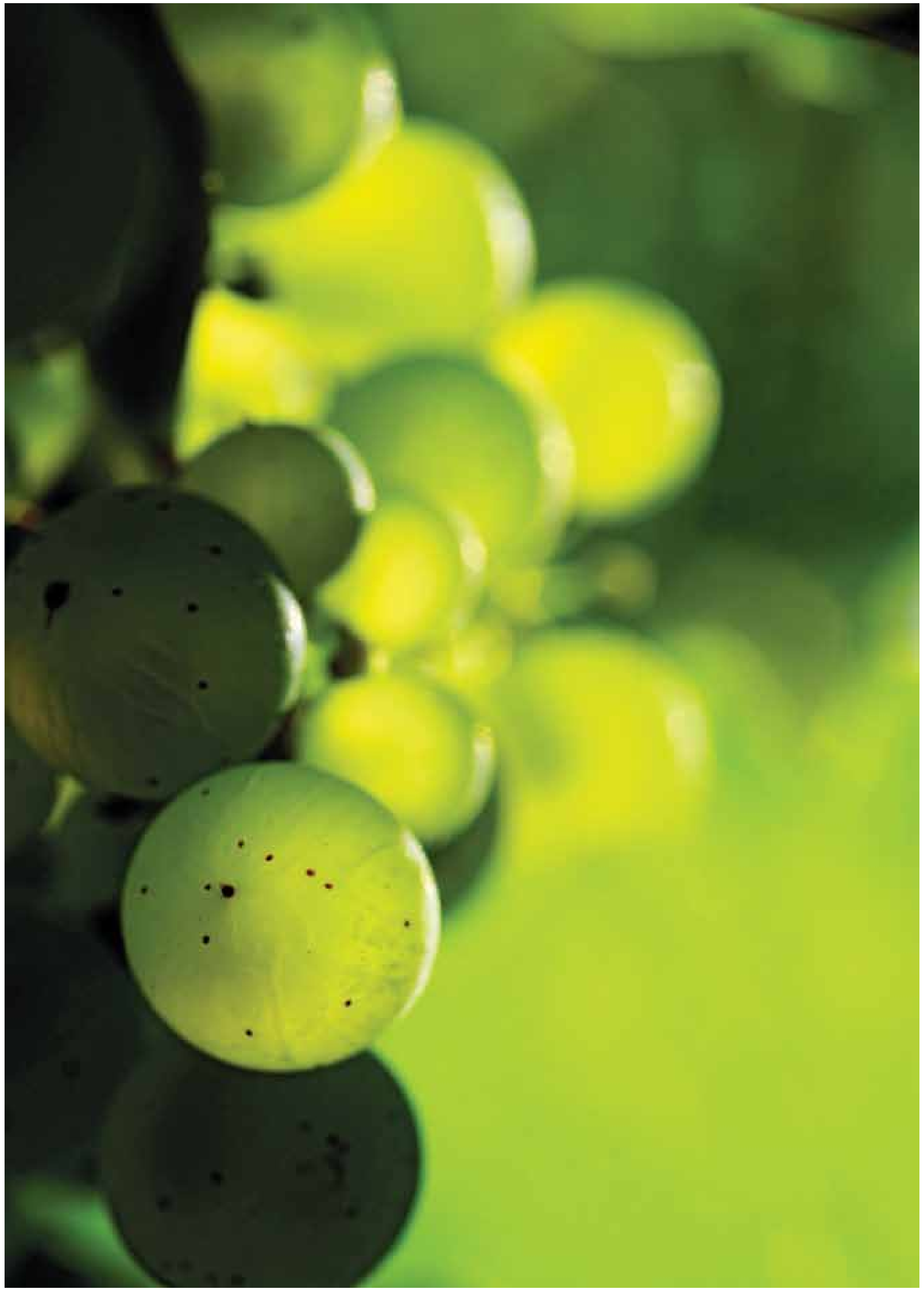
Before embarking on Fischer's findings, a few thoughts on Riesling are in order. It is often said that Riesling is one of the most "transparent" varieties where soils are concerned, unfettered as it usually is by oak flavors and untouched by any aromatic transformations brought on by lactic acid bacteria. Unlike a red wine, its flavors are unobscured by tannins, even when skin contact serves as a pH buffer; on the contrary, this adds varietal flavors in the form of terpenes that reside in the grape skins. Moreover, Riesling often comes with residual sugar, which even in very small amounts almost always acts as a flavor enhancer, even in so-called *trocken* (dry) wines. It is also among the grape varieties most often described as "mineral." Whatever this term may convey, its frequent use suggests that Riesling has numerous indescribable aromas that change particularly and strikingly with the kinds of soils in which it was grown. Of course, it is a short and perhaps even forgivable jump to the wishful conclusion that these indescribable aromas must be those of the soils themselves—of the earthy and reddish-brown Rotliegendes of Niersteiner Pettenthal; the bulky, black, and seemingly smoky basalt of Forster Pechstein; the white-flecked quartzite of Rüdesheimer Roseneck; the porous and pale limestone of Westhofener Kirchspiel; the jagged, bluish-gray Devonian slate of Grünhäuser Abtsberg.

If only flavor chemistry were so simple; if only we could smell those very stones, distill their essence and understand the mystery that is Riesling. That different soils, together with numerous other variables, have an effect on the aroma and flavor of wine is not in doubt. We know, however, that what we smell and taste in the wine is not blue or red slate or sandstone or schist at all, since any directly related minerals that may have found their way into the wine are well below the human perception threshold.

The effects of terroir

Being German and a former Fulbright Scholar at UC Davis under the groundbreaking sensory chemist and inventor of the flavor wheel Professor Ann Noble, Fischer was perhaps predestined to study the effects of terroir—or had we better call it soils?—on Riesling. Hitching his premise to this ill-defined, overused, and often misused concept, Fischer's reasoning is, "If terroir has a sustainable impact on the sensory expression of wine, this unique combination of natural aspects of the vineyard will be a unique selling proposition in the global marketplace." It follows that "terroir yields an individual sensory profile, which allows the production of diverse wines of higher quality. This forms the basis of a regional realization of added value." Fischer's definition of terroir is "the sensorially perceptible dimension within a wine, created by the interactions between grapevine, bedrock, and soil type, topography, and mesoclimate," influenced "indirectly" by the winemaker "via viti-vinicultural practices." Most importantly, though, said Fischer, "the sensory is the bridge between the winemaker and the consumer."

While most of us intuitively know that there is a connection between soil and aroma and flavor, Fischer's concern



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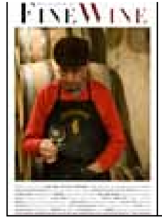

is that these concepts are often nebulous for the consumer. He thus wanted to have objective proof that there was such a connection: "We keep saying that 'terroir' significantly shapes the taste of wine, so when I am speaking of that shape, it is important that this can be smelled and tasted. This is why we have applied sensory chemistry here, in order descriptively, at an objective level, to illustrate the differences between the wines of different terroirs of Riesling," he explained. Fischer is emphatic that this is purely descriptive and not qualitative—sensory analysis in the sense of liking, or disliking, or of awarding medals does not come into it. His, and his team's, sole aim is the objective, descriptive analysis of sensory attributes as they relate to different soils.

To establish a relationship between terroir and its sensory fingerprint on the wine, Riesling grapes from 25 different sites were harvested. One lot of each was micro-vinified under standard conditions at the research institute; the other lot was vinified by the respective vineyard owners in their usual ways. A panel of trained and tested tasters established a set of 14 olfactory attributes, five additional retronasal attributes, and one color attribute that were observed repeatedly in Riesling wines. The panel then agreed on shared definitions of what these attributes were, so as to equalize individual interpretations—of mango or fresh apple, say—and a series of blind tastings followed.

Field work

The first illustration was of two Pfalz sites, just 2km (1.2 miles) apart: Deidesheimer Kieselberg, a site of weathered sandstone and sand; and Forster Pechstein, a site known for its high basalt content amid clay and loam, both vinified by Bassermann-Jordan. It must be noted here that traditionally Pfalz wines are dry, with total acidity levels of 7–9g/l and residual sugars ranging between 3 and 7g/l—that is, below the legal threshold for *trocken*, which lies at 9g/l. The wines from the cooler 2004 vintage showed marked differences between the two sites, Pechstein exhibiting strong tropical fruit, melon, peach, and citrus aromas, Kieselberg coming across with a harder mouthfeel, less aromatically intense and sour. In the warmer 2005 vintage, the differences between the sites were still discernible but far less pronounced, with the famous smoke of the Pechstein coming to the fore. Fischer and his team concluded that there was "a window of optimal maturity for sensory expression of terroir," lying somewhere between 90° and 100° Oechsle, or 12–13% of potential alcohol by volume. The 2004 wines from these sites were also retasted after one and four years, respectively. The Kieselberg displayed hardly any variation in its restrained aromas and rather harsh mouthfeel, whereas the Pechstein was again more expressive in the honey/tropical fruit/melon spectrum and had even more pronounced citrus notes after four years, and more buttery notes but less smoke. Thus, the site differences are perceptible in young and aged wines, even though they are more so in cooler years. This also explains why it is the cooler, more marginal regions of the world that have traditionally been obsessed by ideas of "terroir."

The same taste tests were run with another set of Pfalz wines vinified by Ökonomierat Rebholz. The sites this time, just 1.5km (0.9 miles) apart, were Siebeldinger Sonnenschein (sandstone) and Birkweiler Kastanienbusch (upper Rotliegend, a rigosol/rhyolite formation). While Kastanienbusch was more pronounced in the peach/tropical/honey/melon spectrum, Sonnenschein showed more restraint, a harsher mouthfeel, more acidity, but similar citrus notes. What is striking, though, are the congruent spider-graphs when the two sandstone sites—Kieselberg and Sonnenschein—are compared, with Sonnenschein showing a touch more florality, boxwood, and smoke. Fischer then showed the spider graphs of two Rotliegend sites, this time micro-vinified at the institute: the Birkweiler Kastanienbusch in the Pfalz, and the Ürziger Würzgarten from the Mosel. The similarities here are striking, proving that tasters—and drinkers—are not being fanciful if they consistently find Rieslings from Rotliegend soils, whether from the Mosel or the Pfalz, very expressive.

Fischer followed this with a table summarizing the most significant markers for Riesling in certain soils:
Basalt: lemon/grapefruit, mineral, smoky, cantaloupe, peach/apricot, smooth acidity;
Sandstone: lemon/grapefruit, boxwood, green grass, harsh acidity;
Limestone: mango/passionfruit, peach/apricot, honey/caramel, smooth acidity;
Rotliegend: honey/caramel, cantaloupe, peach/apricot, rhubarb, floral, smooth acidity;
Greywacke: lemon/grapefruit, green grass, dominant acidity;
Slate: apple, lemon/grapefruit, green grass, boxwood, distinctive acidity.

Fischer also commented on perceived "minerality." Again, the word is troublesome, but for lack of a better term, let's stick with it. Fischer pointed out that there is a distinct difference between the aroma perception and the flavor perception of minerality. "Wines that have strong 'mineral' odors do not necessarily have a strong mineral impression on the palate, and vice versa," he asserted. "Minerality in taste has a lot to do with acidity, while minerality in smell is a different matter, a little more connected to boxwood and lemon but little to do with the taste of minerality."

Fischer's studies also correlated soils, meteorological, and sensory data, based on 17 soil/climatic parameters and 19 defined sensory attributes, establishing an explanation for the sensory variation. The aroma of cantaloupe melons, for instance, can be correlated with the calcium and clay content of the soil, the growing degree days, plant average water, and summer days (defined as days with temperatures above 20°C [68°F]). Fischer thus concluded that "in all years, significant differences were observed between different vineyard sites in the standardized as well as the winery-vinified wines" and that "year-to-year variation did not override the general sensory terroir expression, which seemed to be stable over four

A stone carving celebrating the famously high basalt content of the Forster Pechstein vineyard in the Pfalz

Photography by Jon Wyand

years of bottle aging." For Fischer, these results "should help us to distinguish different terroirs and will enable us to improve the communication of this complex matter to consumers." He also affirmed that "terroir goes beyond individuality—it is all about recognizable typicity, related to unique vineyards or regions." And while most of us may have suspected as much, the sensory proof provided by Fischer and his team is welcome vindication.

The terroir of yeast

The second part of Fischer's richly detailed presentation, spurred on by a recent article in the *New York Times* (November 13, 2013), was titled "Terroir of Yeast? Signature of Spontaneous Fermentations." The *New York Times* piece had reported UC Davis microbiological research, hailing a "plausible aspect of terroir that can be scientifically measured," namely that "grape varieties from various wine-growing regions carry distinctive patterns of fungi and bacteria." Fischer quoted the original research conducted by Bokulich, Thorngate, Richardson, and Mills, demonstrating "grape-associated microbial biogeography is non-randomly associated with regional, varietal, and climatic factors across multiscale viticultural zones"—in short, they had found that "four distinct vineyards in Napa varied in their microbial footprint: fungal microbiota including yeast." Fischer then reminded us that so-called wild yeast was in fact made up of numerous yeast strains such as *Candida stellata*, *Kloeckera apiculatus*, *Pichia membranaefaciens*, and so on, but that the yeast populations in fermenting wine change as dissolved oxygen and alcohol levels change, and that around 4% ABV, *Saccharomyces cerevisiae* "becomes the major yeast in a spontaneous fermenting wine." Fischer then expressed his surprise at the wide reporting of these UC Davis findings, since similar studies at Geisenheim had identified very different microbial populations for the same site in consecutive years. His team's own research had already asked whether spontaneous fermentation results in a different wine if conducted under everyday circumstances in the winery or under sterile conditions in a laboratory. They thus set out to isolate five different spontaneous yeast populations from five sites with which to inoculate sterile (pasteurized) but high-quality Riesling juice. The results here showed that there were minimal differences in the flavor profiles of this same wine fermented with different vineyard yeast populations. While the pasteurization may have muted the fruit, the vineyard yeast populations—which differ mostly in the numerous strains that cannot survive beyond a certain low alcohol level—did not differ much in their impact. Fischer hinted that cellar yeast populations were likely to have more impact. Fischer explained that there is more than one way of capturing any additional complexity that spontaneous fermentations may confer upon wine, even without the risk of a stuck fermentation or unwanted residual sugar: "True" spontaneous fermentations, said Fischer, are the result of a random yeast population from the vineyard and the cellar, and then there is the age-old possibility of a *pied de cuve*, whereby sound, clean,

Dr Ulrich Fischer, explaining that "the sensory is the bridge between the winemaker and the consumer"

Photography courtesy of the German Wine Institute / www.germanwines.de

and healthy grapes are harvested ahead and start a ferment that is then used to inoculate the rest of the harvest, or where a healthy spontaneous fermentation is already under way and used to inoculate new ferments. Any spontaneous ferments, once the "interesting" native yeasts have done their work and begin to die, can then also be inoculated with cultured strains that reduces the risk. Fischer concluded that there was "interesting evidence that the micro-flora on the grape varies with grape variety, region, and vintage. However, no information is available as to how this diversity contributes to the sensory properties of wine."

A heads-up on petrol

The third and final part of Fischer's presentation was dedicated to the aroma often described as "petrol" or "kerosene" in aged or warm-vintage/origin Riesling. While some love this unique marker for Riesling, others hate it, and Michel Chapoutier, in his typically uncompromising style, has decried it a fault. Fischer had dug out the 2011 headlines: "Riesling should never smell of petrol. That is a result of a mistake during winemaking," Chapoutier had thundered, declaring it "absurd" that "historical defects should be accepted as part of the character of the wine." One hopes he is actually better informed than that!

The compound giving the aroma is 1,1,6-trimethyl-1,2-dihydronaphthalin, usefully shortened to TDN. It is a well-known fact that TDN is developed in Riesling if there are enough precursors in the skin of the grapes, depending on their exposure to sunlight combined with high temperatures and water stress. These non-volatile precursors then form both free and bound TDN, whose expression in the finished wine is also accentuated by high acidity. TDN is thus more common in Rieslings from riper years or warm climates. Fischer showed data from the Australian Wine Research Institute for measured TDN levels in Australian Rieslings. Concentrations vary widely within regions, probably depending on site and fruit exposure, with sunny Eden Valley clocking up the highest maxima: Up to 255 micrograms/liter were measured. While some Australian Rieslings show very low TDN readings of as little as 2 micrograms/liter, the lowest median values of 36 micrograms/liter were observed in Adelaide Hills Riesling. Notably, this rather low reading for Australia is still higher than any TDN level measured in 27 vintages ranging from 1959 to 2010 in aged Riesling wines from the Staatsweingut mit Johannitergut in the Pfalz. Here the highest reading was 19 micrograms/liter in the warm 2005 vintage.

Fischer brought along a fine specimen of a wine redolent of that gas-station-forecourt scent—covered glasses went around the room and everyone took a sniff—and the smile of recognition was on many faces: surely our old friend Riesling. But Fischer had the last laugh; impishly he had spiked a bottle of basic Chardonnay, from UK supermarket Sainsbury's, with TDN—just to show us how uniquely, and for many of us how wonderfully, this aroma is associated with Riesling.

Since there is both bound and free TDN in Riesling, Fischer showed an interesting slide likening free TDN to the tip of an iceberg, with bound TDN submerged beneath the surface. "Bound aroma compounds are released during fermentation and aging. They form a reservoir of varietal flavors, but also of aging flavors," he explained. "When you can smell TDN in a wine, you know that it is going to become more intense with time, as more bound TDN is released. At the same time, free TDN is dissipated, so the wines are in a constant state of flux. After five years, however, most wines reach a sort of peak and stay roughly stable for a decade and then TDN levels recede again, as free TDN is dissipated and the reserves of bound TDN are used up—when the iceberg has melted, so to speak. However, some vintages simply have more TDN than others." This life cycle of TDN was perfectly illustrated by a comparison of bound and free TDN in Mosel Riesling (the particular wine is not specified; research by H Rudy et al, 2011, DLR Mosel) measured in vintages ranging from 1952 to 2003. Notably, the highest measured level of free and, therefore, perceptible TDN was only 14 micrograms/liter in a wine from the hot 1976 vintage.

TDN levels can be influenced by viticultural practice, especially canopy management; whether or not the fruit zone is shaded makes a big difference, as does the timing of leaf-plucking. Fischer presented 2010 research by Kwaniewski, Pan, Van de Heuvel, and Sacks, published in the *Journal of Agricultural and Food Chemistry*, showing that pre-veraison leaf removal led directly to higher total-juice TDN. However, Fischer's current research is concerned with developing a yeast strain that can counteract the formation of TDN. Skin carotenoids in Riesling grapes form the flavor precursors of TDN. Research has shown that certain yeasts can reduce these precursors so that they develop into vitispirane rather than TDN. "While TDN has a perception threshold of 20 micrograms/liter, vitispirane has a threshold of 800 micrograms/liter," explained Fischer. "Thus, even if I am in Australia, where I can reach levels of 255 micrograms/liter of TDN, if this is vitispirane instead, I cannot smell it." Since many perceive the TDN aroma as unpleasant, such yeasts may find a ready marketplace.

As Fischer concluded, a lively discussion ensued. Dr Franz Werner Michel of the Domdechant Wernersches Weingut in the Rheingau and former chairman of the German Wine Institute, who celebrated his 81st birthday in September 2013, commented on the sad fact that, in Germany at least, tertiary flavors in Riesling were not always appreciated. He fondly remembered his youth, when *Firne* was what people looked for in Riesling. This untranslatable term describes the indescribable—the developed bouquet of Riesling—and other wines. With minds freshly filled with facts and even more in awe of the still-uncharted intricacies of nature and Riesling, we proceeded to dinner—and congratulated Professor Dr Fischer on his amazing insights. His work will never be finished. *Prost* to that!