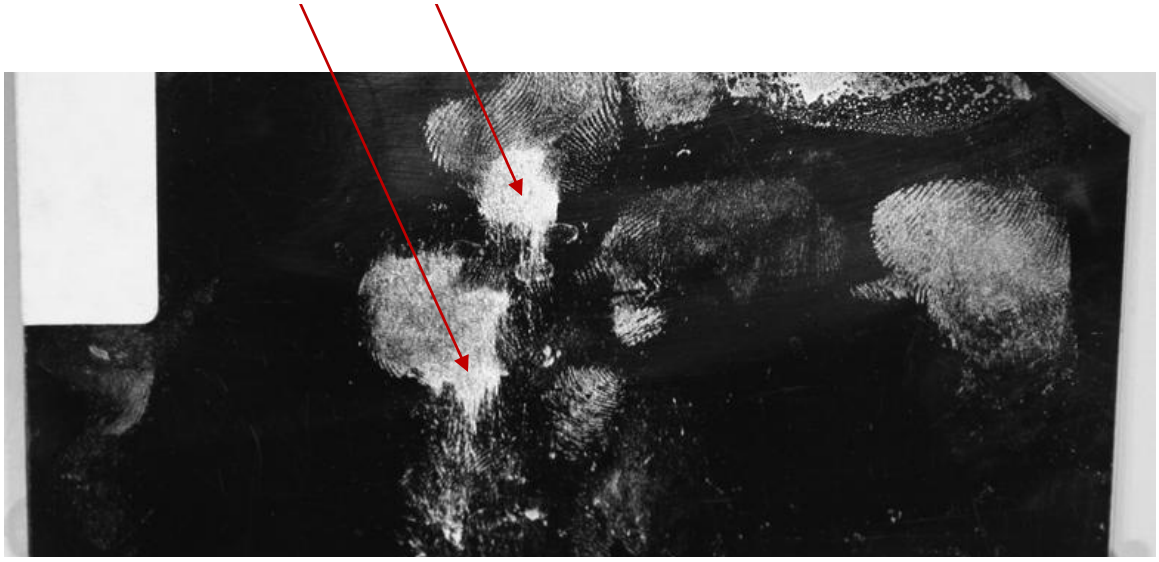
THE WET DROPS ON FOLIEN 1

Folien 1 shows that there were two wet drops (of an unknown substance) on the substrate at the time it was dusted. Mr Wertheim and Mr Zeelenberg used the presence of these two drops, in addition to the dry drops, as further substantiation that the substrate came from a wet environment such as a drinking glass.

Using actual climatic conditions on the day of the murder and applying drop evaporation theory, and considering water as substance, we will show that any normal sized wet drops that may have been in the apartment at the time that the accused left the apartment at 7:30 or at the time of Inge's death would have dried by the time that she was discovered, and therefore that any wet drops on the substrate were deposited after the discovery of the body and shortly before the dusting took place.

Could these drops have stayed wet on a vertical inclined surface from any time before the murder until the time of dusting(when it was smudged) – a lapse of at the very least 6 hours? Or could they have been deposited much closer to the time of dusting on any surface?



Climatic conditions on the day of the murder

The murder occurred on 16 March 2005 between 15:30 and 18:30.

The following climatic indicators were recorded at Cape Town International Airport (the then D.F. Malan Airport) on March 16, 2005[1]. As the crow flies, the airport is about 20 km from Stellenbosch.

Mean temperature = 21.2 °C (70.1 °F)
Maximum temperature = 34.2 °C (93.7 °F)
Minimum temperature = 15 °C (59 °F)
Mean sea level pressure (hPa) = 1011.7
Mean humidity = 87 %

No rain was recorded.

Drop evaporation theory

The formula to determine the evaporation rate (m^3/sec) of a sessile drop is (Sobac and Brutin, 2011):

$$Q = 4\, D_v\, R_s\, C_v(1\text{-}H/100)\, f(\theta)$$

H – Relative Humidity (%)
D_v – Diffusion coefficient of water vapor in air (m^2/sec)
R_s – Water surface radius (m)
C_v – Saturated vapour concentration (kg/m^3)
f(θ) – Function of contact angle

Once the rate is known the drying time can be determined from the following formula:

$$t_f = V/Q$$

V = Volume of drop

i) Relative Humidity

The average humidity on 16 March 2005 was 65 %. Therefore we will use **H = 65%.**

ii) Diffusion coefficient

The following equation can be used to determine the diffusion coefficient of water vapour in air[2]:

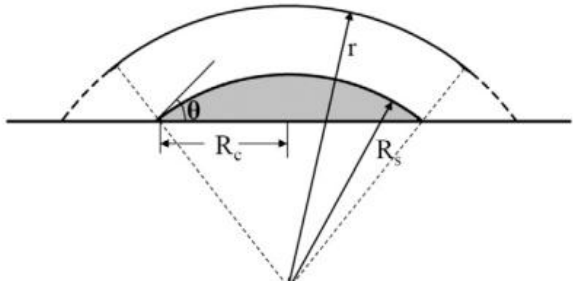
[1] http://www.tutiempo.net/en/climate/Cape_Town_D_F_malan/03-2005/688160.htm

$$D_V = 21.2 \cdot 10^{-6} \left(1 + 0.0071 \cdot T\right)$$

D_v = Diffusion coefficient (m^2/s)
T = Temperature (^oC)

[Error: <0.1x10^{-6} m^2/s; validity range: 0-45^oC]

iii) Water surface radius



Source: Song et al, 2011

The water surface radius can be calculated with the following formula (Song et al, 2011):

$$R_s = \left[\frac{3V}{\pi(1-\cos\theta)^2(2+\cos\theta)} \right]^{\frac{1}{3}}$$

Volume (V) of a drop can be determined by (Wikipedia):

$$V = \frac{4}{3}\pi h\left(\frac{D}{2000}\right)^2$$

H = height of drop (m)
D = drop diameter (mm)

The height of drop can be determined by (Wikipedia):

$$h = \sqrt{\frac{2\gamma_{lv}(1-\cos\theta)}{g\rho}}$$

ρ = Density of drop (1000 kg/m^3)

[2] http://physics.holsoft.nl/physics/ocmain.htm

g = Gravitational constant (9.81 m/^{s2})
θ = Contact angle (radians)
λ_{lv} = Surface tension of water

iv) Saturated vapour concentration

Saturated water vapour pressure (Pascals) in air can be determined from the following empirical equation[2]:

$$p_{sat} = 610.7 \cdot 10^{7.5\,T/(237.3+T)}$$

T = Temperature (^{o}C) - validity range roughly 0-80^{o}C.

At T = 21.2 ºC the saturated water pressure is 2517 Pa.

To convert the water vapour pressure to concentration the following equation can be used[3]:

$$C_v = 0.002166 * p / (T + 273.16)$$

p = Vapour pressure

With a vapour pressure of 2517 Pa the concentration is 0.0185 kg/m^3.

v) Function of contact angle f(θ)

H. Song et al (2011) recommend the following function for a water drop drying on slide glass:

$f(\theta) = 0.338 + 0.0064\,\theta$

θ = Contact angle (radians)

vi) Contact Angle

For water glass is a hydrophilic surface i.e. $\theta < 90^{o}$

There are no standard values for the contact angle between glass and water. The contact angle is extremely sensitive to surface properties, fluid composition and additives. In addition surfactants, originating from household cleaning products e.g. dishwashing liquid, also has an impact on contact angles. It is not unrealistic to assume that a normal

[3] http://www.conservationphysics.org/atmcalc/atmoclc1.php

drinking glass has been in contact with and may be impacted by the presence of surfactants.

However the general consensus is that the contact angle is low, often even zero or close to zero.

In reality it is evident that the angle is not quite zero, or else we won't ever find spherical water drops attached to glass surfaces. Lunkad et al (2007) reports a static contact angle of between 6 and 10 degrees for water on glass.

Due to the uncertainty in contact angles analysis, we will investigate a range of contact angles between 5^o and 90^o.

vii) Surface Tension

The surface tension of water depends on its temperature. Vargaftik et al (1983) provides the following values for the surface tension of water at different temperatures.

Water Temperature	**Surface Tension N/m^2**
0 ^oC	$74.95 * 10^{-3}$
10^oC	$74.23 * 10^{-3}$
15 ^oC	$73.50 * 10^{-3}$
20 ^oC	$72.75 * 10^{-3}$
25 ^oC	$71.99 * 10^{-3}$

To be conservative and to be consistent with water drops possibly originating from a fridge, surface tension of (γ_{LV}) of $73.50 * 10^{-3}$ will be assumed.

RESULTS

The Table below shows the drying time for an assumed 4.5 mm diameter circular drop on glass at an ambient air temperature of 21.2 °C at a humidity of 65 %.

A typical contact angle of water is between 0 and 30 degrees – thus the most likely drying times are represented by the green shaded area.

Contact Angle	h	V	Dry Time (sec)	Dry Time (hrs)
5	0.0002	5.06E-09	1475	0.4
10	0.0005	1.01E-08	3229	0.9
15	0.0007	1.52E-08	4980	1.4
20	0.0010	2.02E-08	6704	1.9
25	0.0012	2.51E-08	8387	2.3
30	0.0014	3E-08	10018	2.8
35	0.0016	3.49E-08	11585	3.2
40	0.0019	3.97E-08	13080	3.6
45	0.0021	4.44E-08	14494	4.0
50	0.0023	4.91E-08	15819	4.4
55	0.0025	5.36E-08	17049	4.7
60	0.0027	5.8E-08	18178	5.0
65	0.0029	6.24E-08	19201	5.3
70	0.0031	6.66E-08	20114	5.6
75	0.0033	7.07E-08	20915	5.8
80	0.0035	7.46E-08	21602	6.0
85	0.0037	7.84E-08	22174	6.2
90	0.0039	8.21E-08	22634	6.3

See conclusion on next page

Conclusion: ***It can be concluded that any wet (water) drops in the apartment at the time of Inge's death (between 15:30 and 18:30) would have been dry by the time of her discovery at about 22:30. Any wet drops on the surface to which Folien 1 was applied would have been deposited after her discovery and most possibly very close to the time of dusting.***

Furthermore, whatever the source of the drops (e.g. sweat from a perspiring police officer, sneeze, etc.), the drops could equally likely have been deposited on a horizontal or a vertical substrate. The presence of wet drops therefore lends NO conclusive support to the defence's glass theory. We will never know how they got on whichever substrate. A foline lift alone cannot tell us that. However, science can tell us what happens to drops in certain circumstances and conditions. And on that basis we can make informed deductions. Not by making easy assumptions.

If it is believed that the deposition of the wet drops on the drinking glass was contemporaneous with the use of the glass by the accused, Mr Fred van der Vyver ('whose fingerprints are on the glass'), then that would suggest the possibility that he was in the victim's apartment well after he left the apartment at 7:30 that morning, and possibly even after the murder.

It is also possible that something like sauce or mayonnaise may have be the source of the smudges. Takeaway food was in the vicinity and was consumed shortly before TOD. We do not know and cannot know that the smudges were made by water drops, as the experts simply assumed.

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4. Vargaftik, N.B., B.N. Volkov, and L.D. Voljak. "International tables of the Surface Tension of Water". *Journal of Physical Chemistry*. 12.3 (1983): 817-820.