Optimised Precoats for Multilayer Coating

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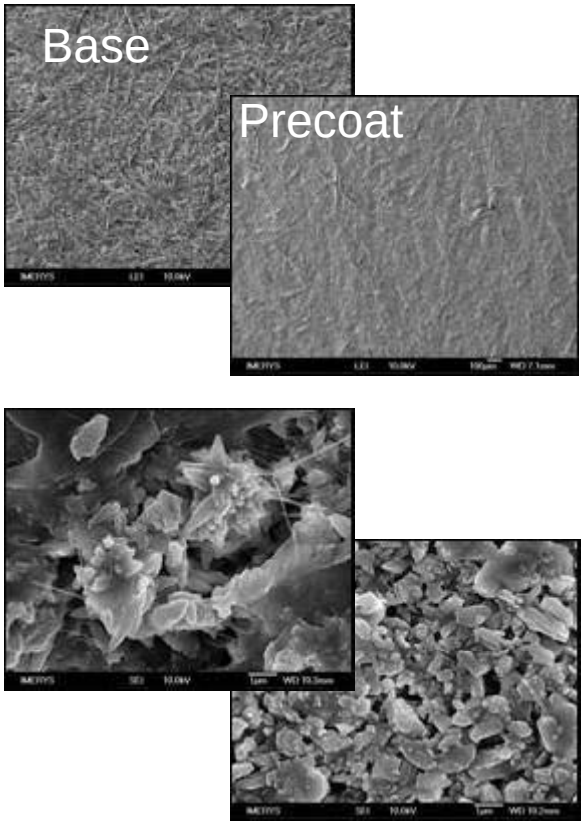
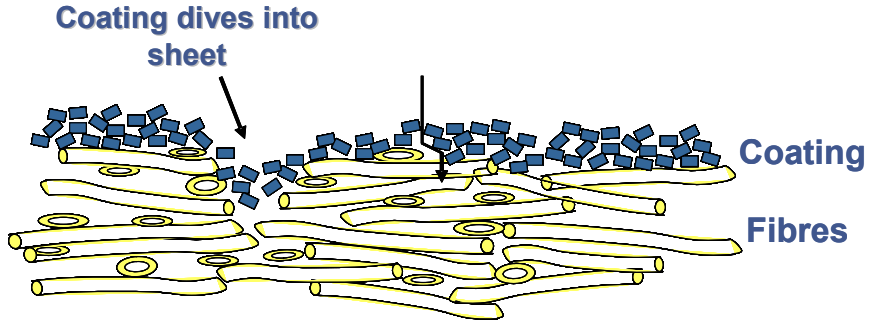
RETHINK PAPER:
Lean and Green

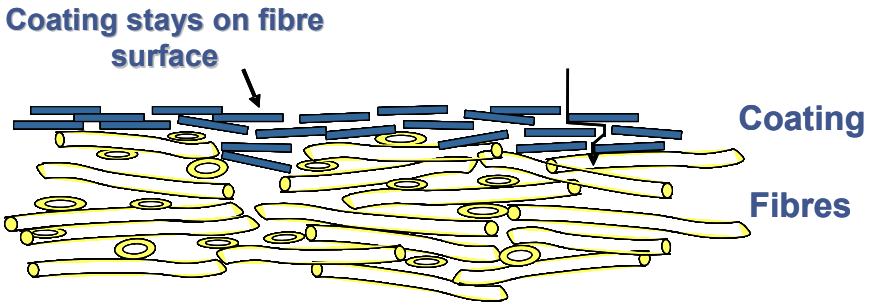
Background

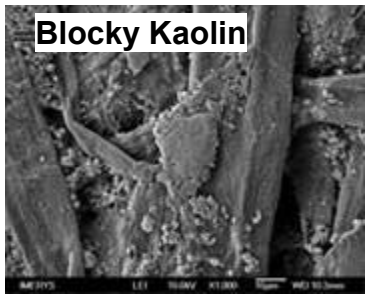


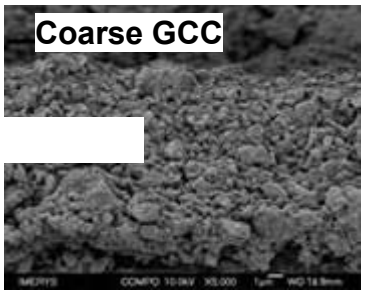
- The role of the precoat is to provide cost effective basepaper coverage enabling application of fine topcoats for gloss and printing
- As kaolin levels in topcoating reduce this puts greater demands on the precoat performance
- In this paper we explore
  - How optimising the precoat through the use of coarse platey kaolins together with GCC can give a bulkier coating and better coverage
  - How this impacts quality and formulation design for topcoating in coated woodfree and coated board applications

Particle Shape and Coverage Effects are well Known



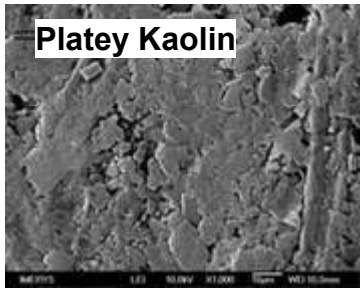


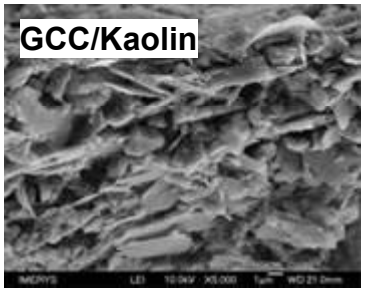




Paper Surface

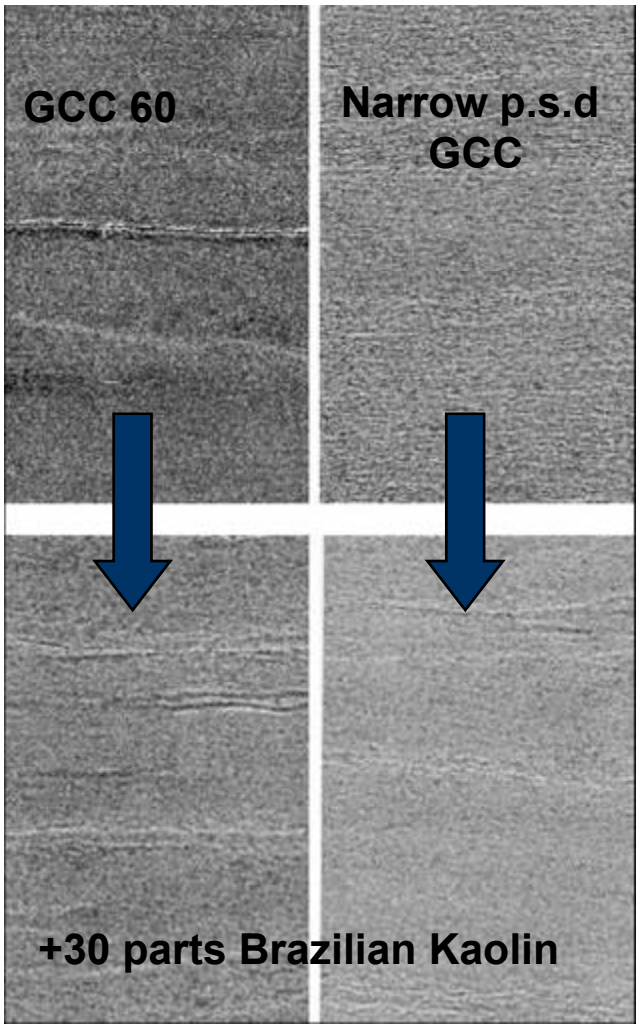
Paper X-Section





- Increasing kaolin shape can give better coating holdout & fibre coverage
- Higher shape kaolins also generate bulkier structures when combined with GCC which can help both physical and optical coverage.

Example: Metered Size Press Precoating



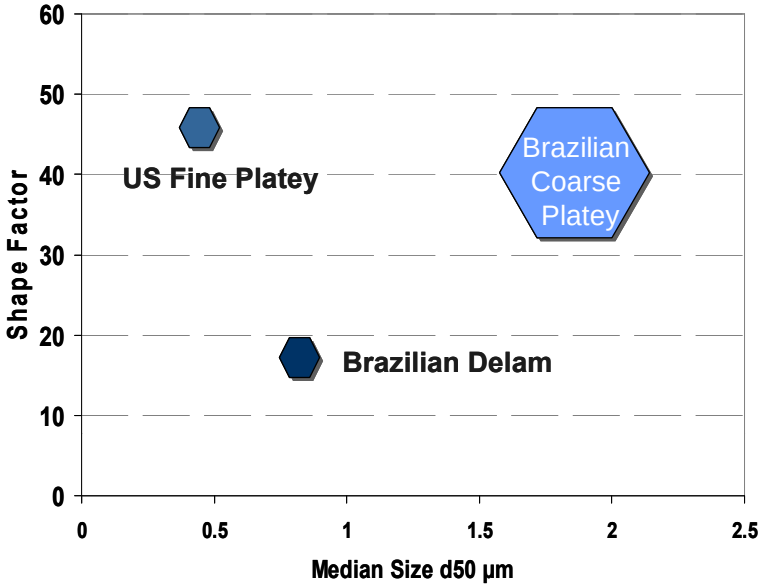
Burnout Images

Formulation	Solids (wt%)	B'ness (-UV)	Opacity	PPS (µm)
Coarse GCC (60)	70.8	85.2	85.6	6.0
Narrow p.s.d GCC (95)	65.6	85.9	86.6	5.7
70:30 Standard GCC/ Platey Kaolin	64.9	84.9	86.6	4.9
70:30 Narrow p.s.d. GCC/ Platey Kaolin	63.1	85.7	87.3	4.6

- Pilot coating 1500 m/min, Latex/Starch recipe,10 gsm

- Significant improvements in coverage and PPS from kaolin addition to precoat
- Bulking effects of kaolin and standard GCC give light scatter and opacity benefits v standard GCC alone
- Further benefits from kaolin and narrow p.s.d. GCC together

Pilot Scale Blade Precoating Studies



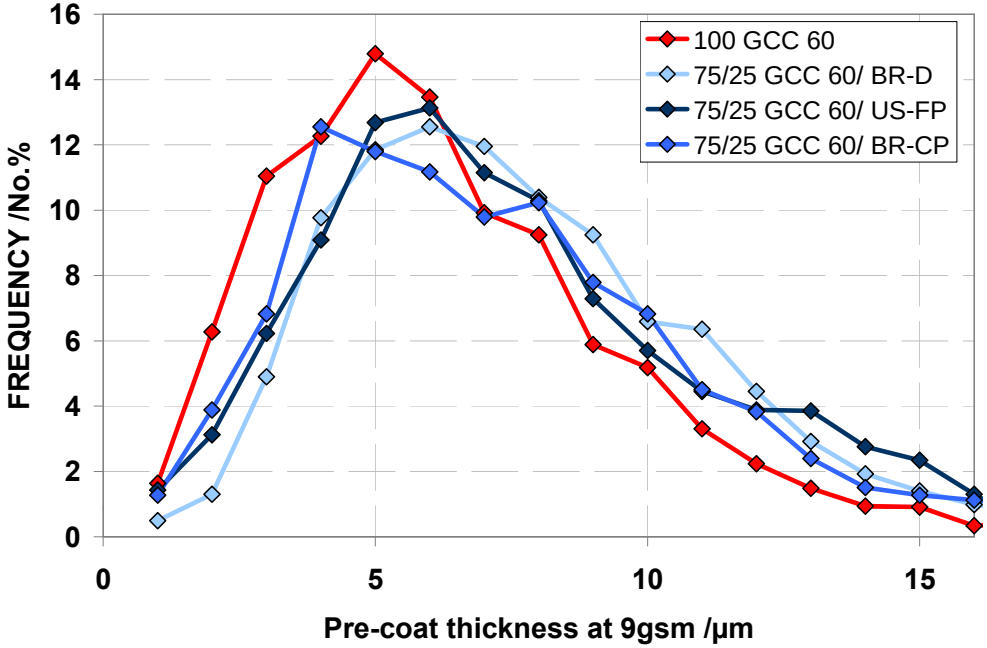
	1	2	3	4
US Fine Platey US-FP				25
Brazilian Delam BR-D			25	
Brazilian Coarse Platey BR-CP		25		
GCC 60	100	75	75	75
Starch	6.0	6.0	6.0	6.0
Latex	6.0	6.0	6.0	6.0
Cross-linker	0.3	0.3	0.3	0.3
Colour Solids %	66.5	65.0	65.5	64.0

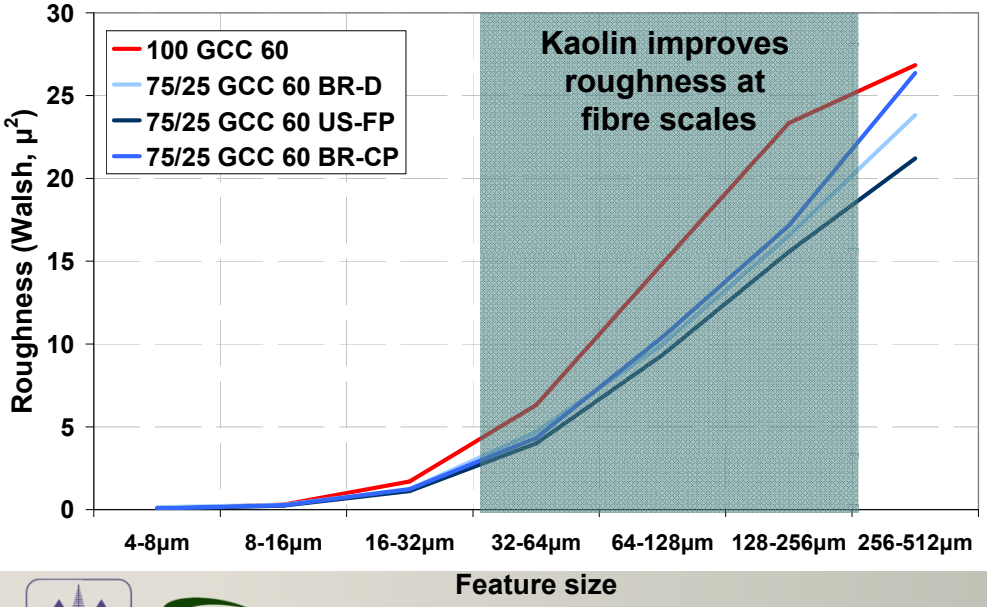
	Wt% -2 µm	B'ness ISO
US Fine Platey US-FP	91	86.5
Brazilian Delam BR-D	78	88.5
Brazilian Coarse Platey BR-CP	53	87.6

- Blade coating at 1200m/min; 45gsm WF base, 9gsm coating
- Coarse and high aspect ratio kaolins evaluated at low levels (25%) in precoat recipe

These papers were used for the topcoating studies described later in the presentation

Coating Thickness and Roughness



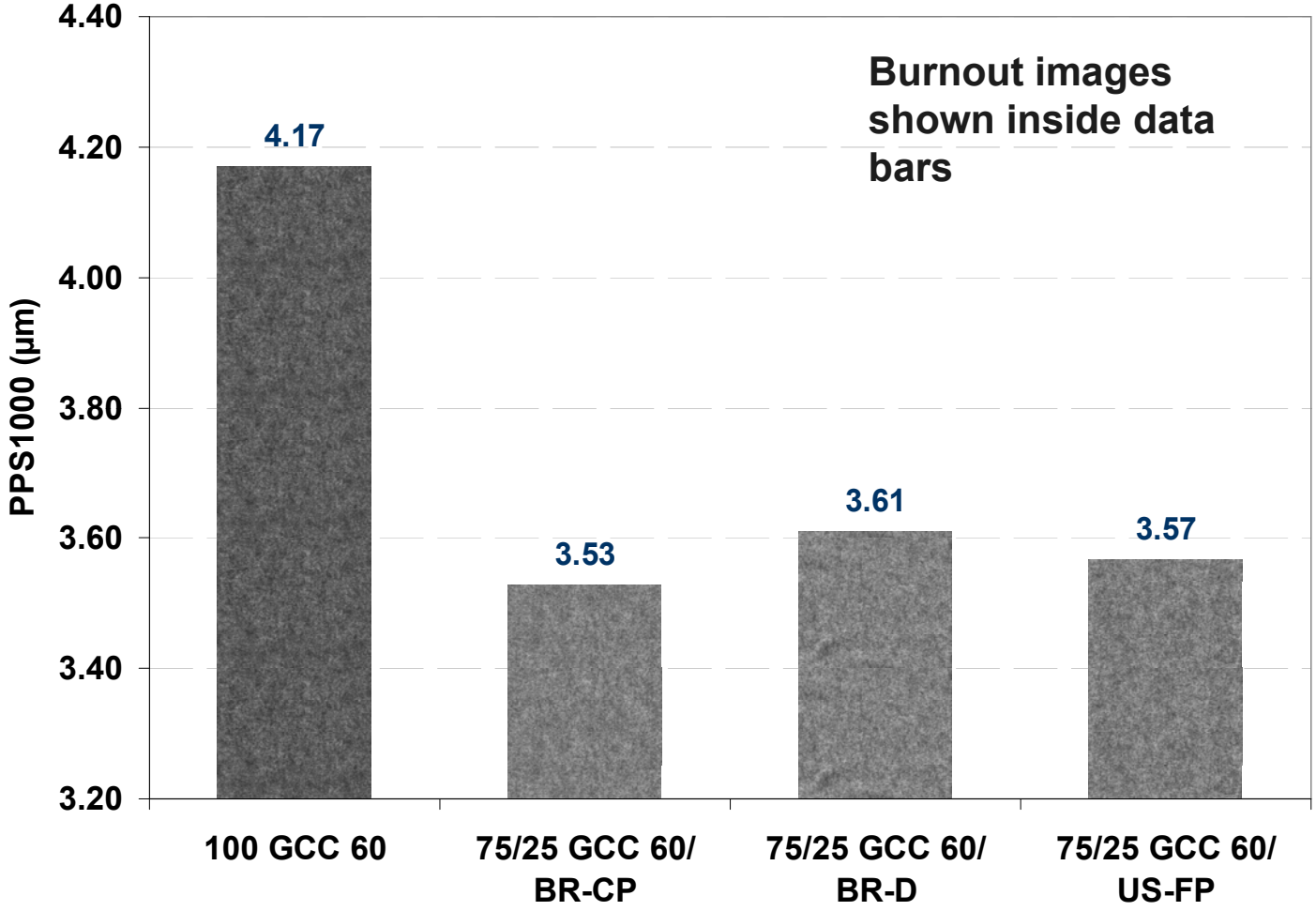


- Analysis of coating thickness distributions using optical microscopy showed significant increases in coating thickness when kaolin is added to the precoat
- Improvement was in the region of 20-25%

	Mean Coating Thickness µm
GCC 60	6.0
GCC 60/BR-CP	7.1
GCC 60/BR-D	7.6
GCC60/US-FP	7.3

- **Laser profilometry and Walsh analysis was used to assess how roughness changed on different length scales**
- **Results showed that kaolin addition improves roughness at fibre length scales**
- **In other words improved coverage…..**

Coverage and Smoothness



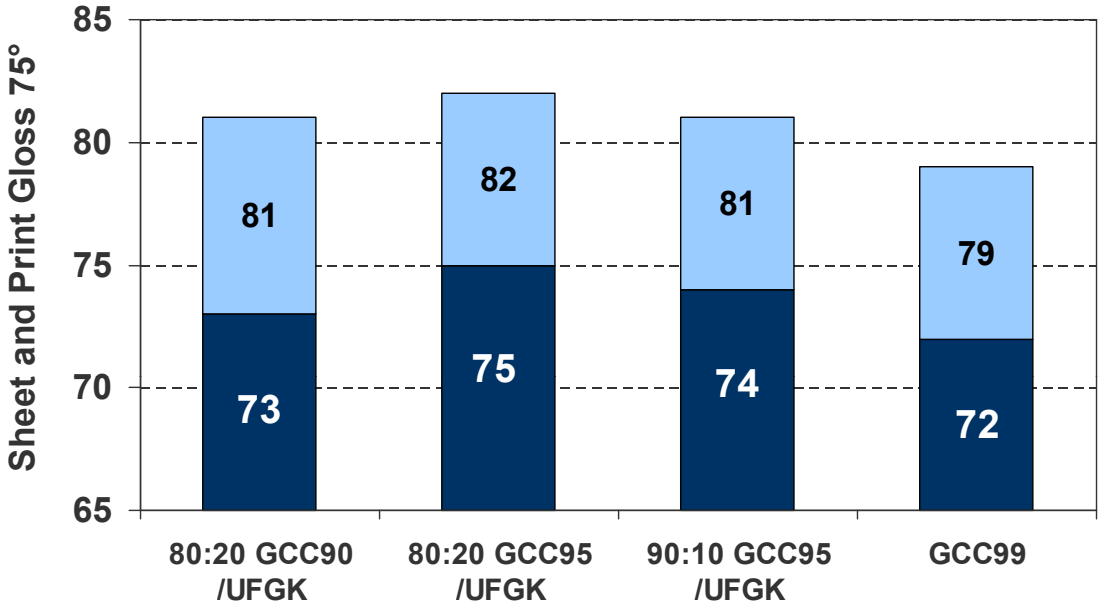
- All of the high shape kaolins gave improved coverage and better smoothness when added to the GCC based precoat.

Influence of Precoat on Finished Paper Properties

Coated Woodfree Examples

Technical Needs in Gloss Topcoating

Sheet and Print Gloss



- **CWF topcoat study**
  - 11 gsm
  - Latex/CMC formulation
  - Range of topcoats with 20, 10 and 0 parts of glossing kaolin

- Kaolin levels in glossy topcoating are typically 20% or less and kaolin-free recipes are now well established in many geographies
- However, achieving sufficient sheet gloss and print gloss can remain a challenge issue with kaolin-free recipes
  - This often requires formulation and calender optimisation to solve
  - Kaolin free topcoats give a smaller operational window and will be more sensitive to base variations

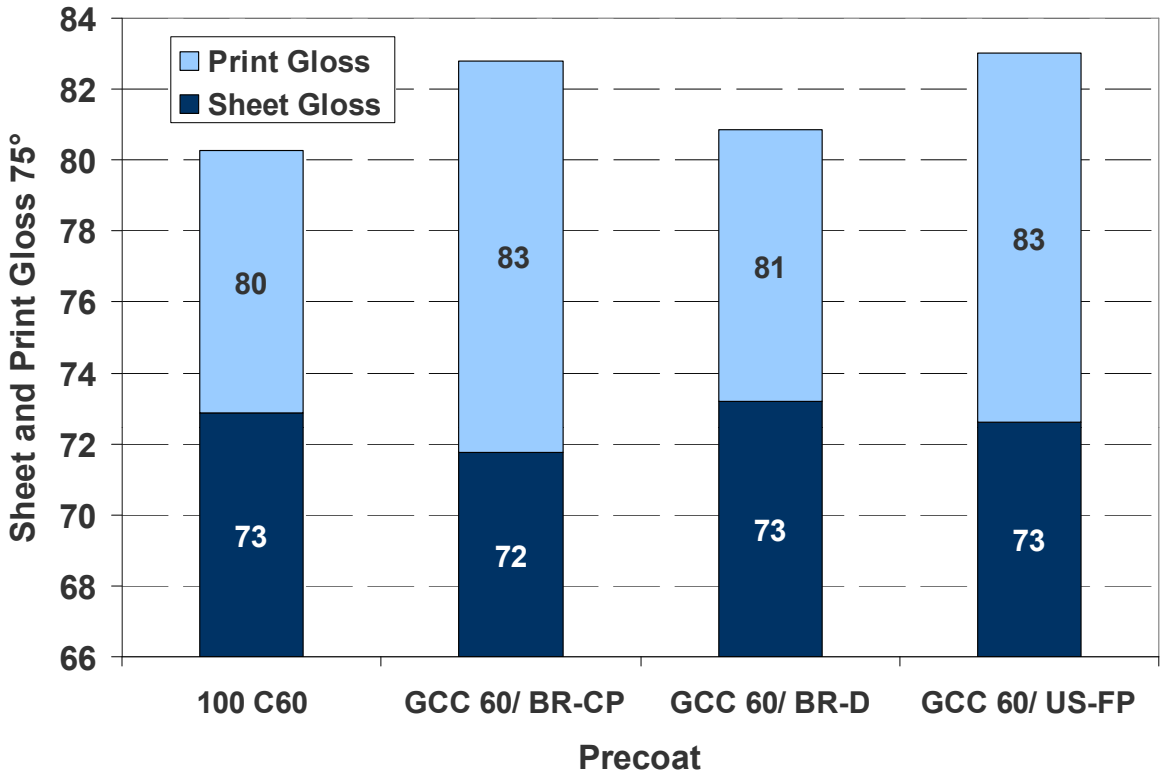
Case Study 1: Glossy Woodfree

Impact of Kaolin in Precoat on Kaolin Free topcoats

Pilot Precoat	1	2	3	4
US Fine Platey US-FP				25
Brazilian Delam BR-D			25	
Brazilian Coarse Platey BR-CP		25		
GCC 60	100	75	75	75
Laboratory Topcoat	**1**	**2**	**3**	**4**
GCC 97	100	100	100	100

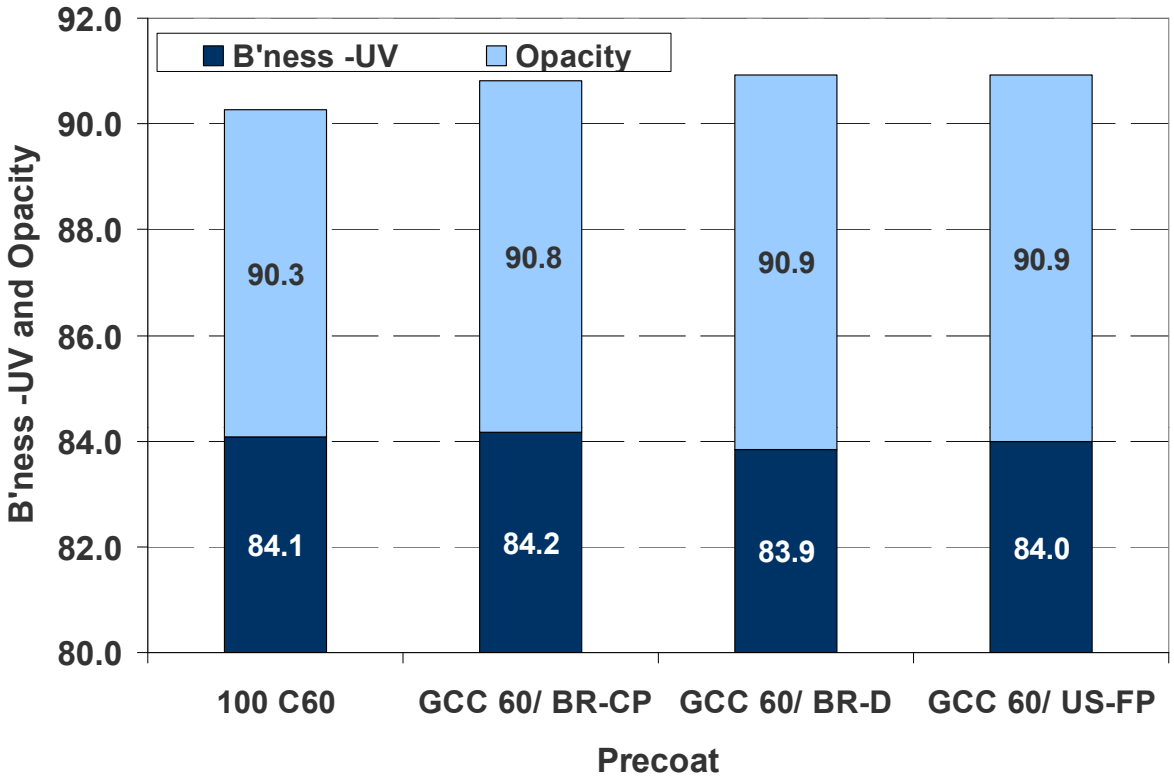
- Pilot precoated basepapers were topcoated with 100% ultrafine GCC
- Coating 1000 m/min
- 11 gsm coatweight
- Latex/CMC Recipe
- Papers Supercalendered to 73 gloss

Results: Gloss and Print Gloss



- Kaolin addition to the precoat in this study had relatively little impact on sheet gloss (although base used in this work was quite smooth with PPS = 5.6 µm)
- However, precoat kaolin addition did improve print gloss by up to 3 units
- Higher aspect ratio kaolins in the precoat were better in this respect

Results: Brightness and Opacity



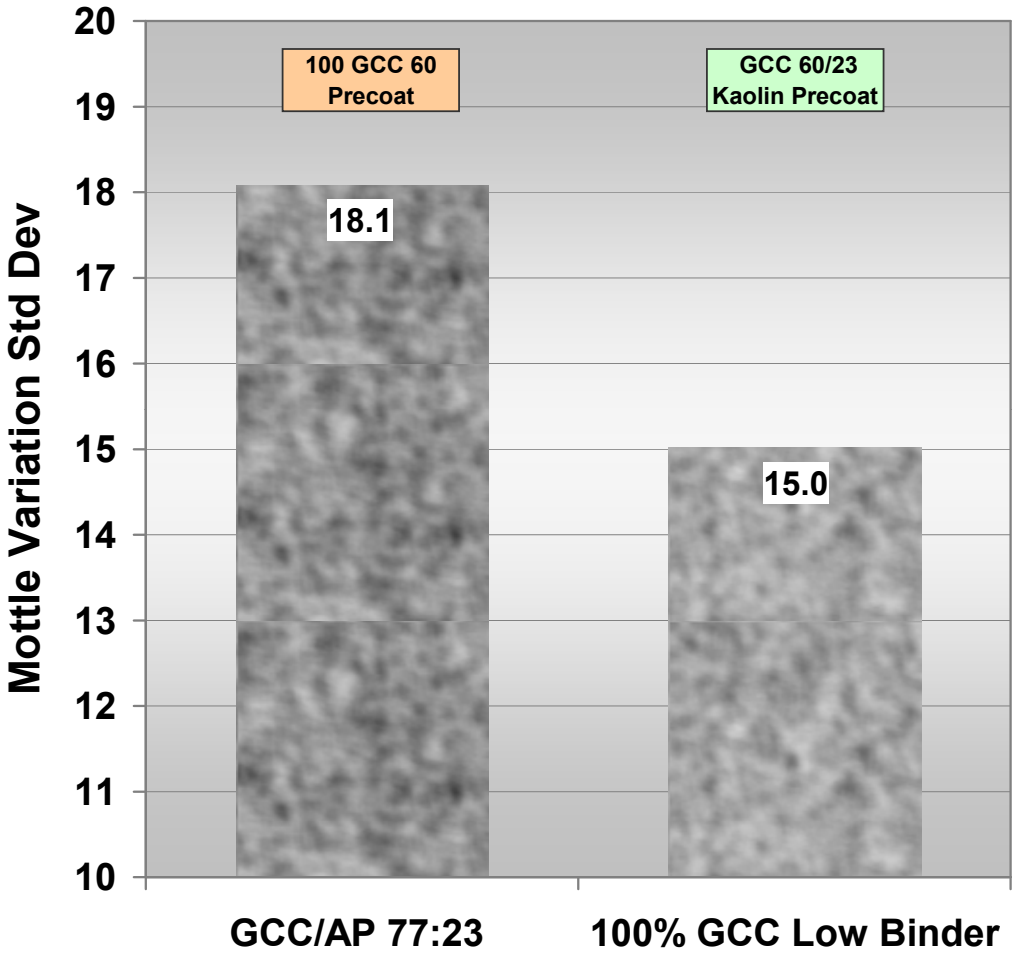
- Kaolin addition to the precoat in this study had relatively little impact on the finished paper brightness in the absence of UV*
- However, precoat kaolin addition improved opacity by > 0.5 units
- This gives more degrees of freedom for calender optimisation for increasing sheet gloss

* Note +UV brightness will be reduced with kaolin in precoat but this will be more than offset by kaolin reduction in topcoat

Case Study 2: Glossy Woodfree

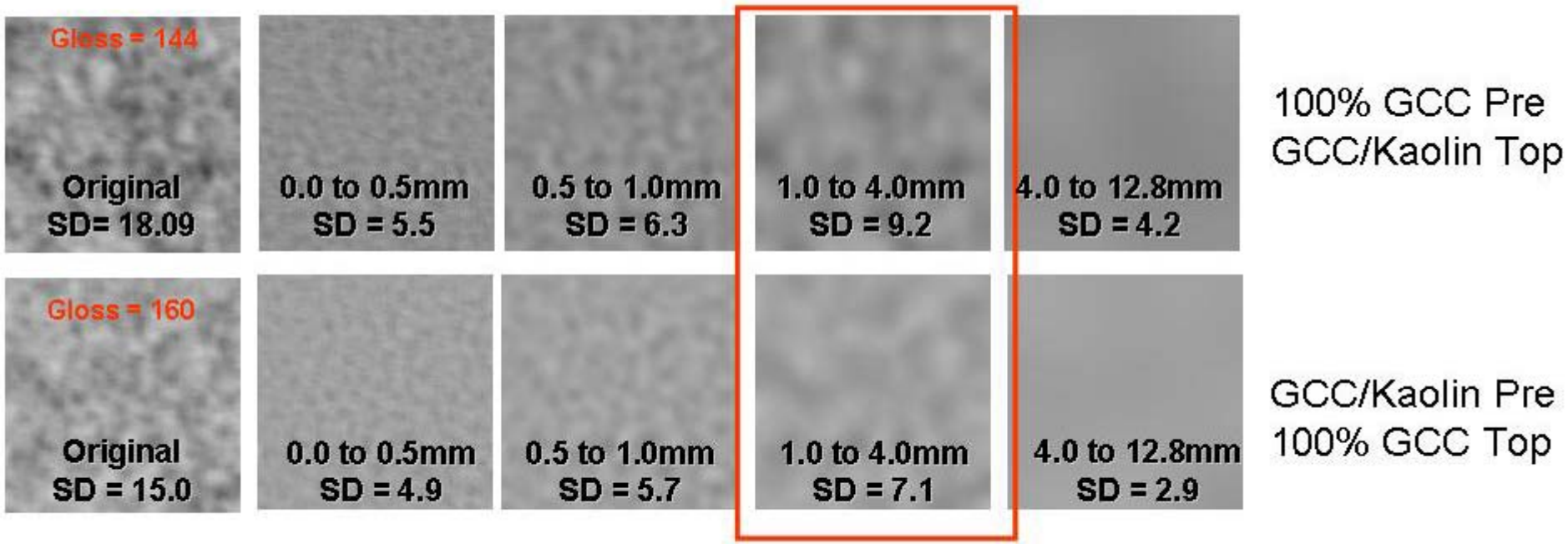
Mottle and Print Quality Improvement

- Pilot double coating study
- 12gsm Precoat and topcoats applied at 1800 m/min
  - 100% GCC 60 Precoat with GCC 95 + 23 parts UF Kaolin Topcoat
  - GCC 60 + 23 parts US–FP Kaolin Precoat with 100% GCC 95 Topcoat
    - with reduced binder, co-binder and PVA
- Gloss and Print mottle assessed



- Significant benefit seen from kaolin in precoat in terms overall gloss mottle

Gloss Mottle Results

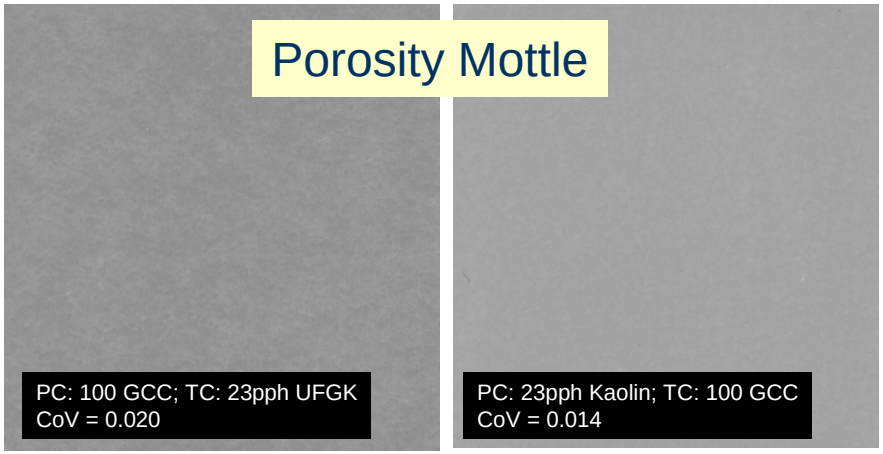


- FFT applied to gloss mottle pattern to break down variance to different length scales
- Lighter shade indicative of higher gloss with kaolin containing precoats
- Most gloss variation (mottle) related to fibre/formation scales
- Kaolin containing precoats clearly reduce the extent of the mottle on these scales Can see biggest variation occurs at formation length scales

- Further more some evidence for higher intrinsic gloss from kaolin in precoat

Contrasting the Concepts: Other Properties

Precoat >>>>	100% GCC	GCC/Kaolin
Topcoat>>>>	GCC/UF kaolin	100% GCC Reduced Binder
Tappi 75 Gloss 10 ° Acceptance	77	72
Reflectometer Gloss 2° Acceptance	52	53
PPS 10 µm	0.60	0.51
D65 B'ness + UV	93.5	97.0
D65 Opacity	94.2	94.0
Print Gloss 100% Black	86*	89*
Delta Gloss 100% Black	9*	17*
Pick Strength cm/s	382	355



- Concept of kaolin in precoat and kaolin free topcoat gave lower apparent gloss but not when low acceptance angles are used
  - Could relate to differences in macro and micro-roughness
- In all other properties performance was similar or better than the standard approach
- Especially true with respect to printing and porosity mottle

Case Studies Summary

- Replacing kaolin in topcoating with 100% GCC is often detrimental to gloss, opacity, and print gloss
- If in contrast topcoat kaolin is replaced, while coarser kaolin is added to the precoat then there is,
  - Potential for improved sheet gloss
  - Clear benefits to opacity
  - Clear benefits to print gloss
  - Clear benefits to mottle
  - Clear benefits to opacity
- All of which give more degrees of freedom in terms of topcoat formulation modification for cost savings or calendering optimisation for gloss
- The effect of kaolin in the precoat is likely to be greatest on rougher and variable basestocks……

Influence of Precoat on Finished Board Properties

A Case Study

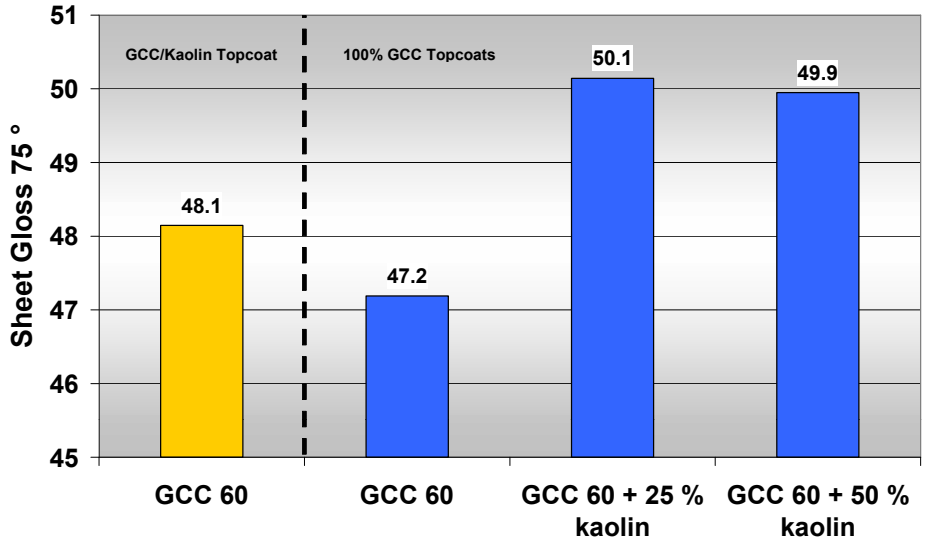
Case Study: Double Coated Board Concepts

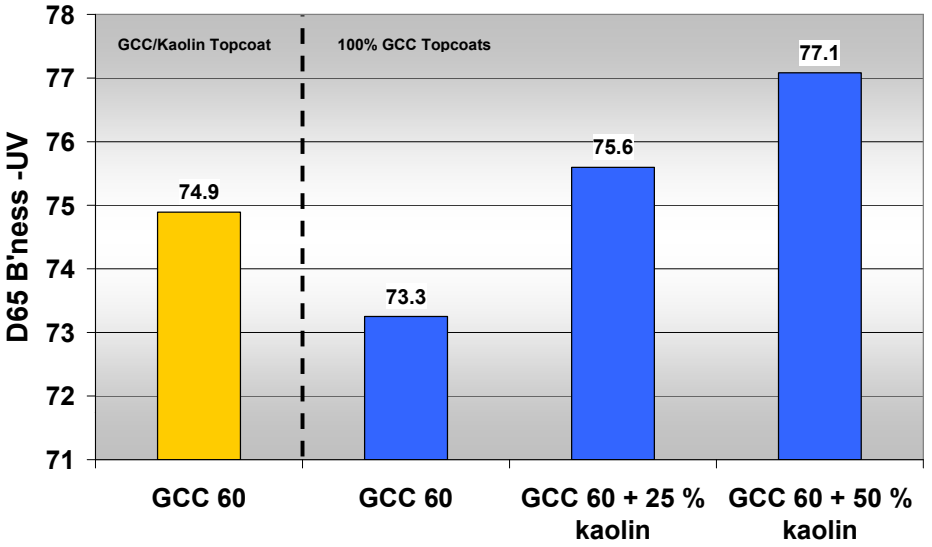
- As before we are contrasting the use of kaolin in the precoat with that in the topcoat
- 190 g/m^2 WLC board with PPS 10 Roughness of 5.2 µm
- 3 precoats applied at Pilot scale
  - 100% GCC 60, 75/25 GCC 60/BR-CP kaolin, 50/50 GCC 60/BR-CP
  - 8 pph Latex, 5 pph starch, 0.5 pph cross-linker
  - 14 g/m^2 at 450 m/min using bent blade
- 2 topcoats applied using laboratory Helicoater
  - 14 parts Latex , 0.3 pph CMC
  - 100% Ultrafine GCC and Fine GCC/Ultrafine kaolin 85/15
  - 600 m/min using stiff blade
- Latex level also varied on selected topcoats 14, 11 and 8 parts
- Board Properties, Optical coverage and cracking tendency investigated

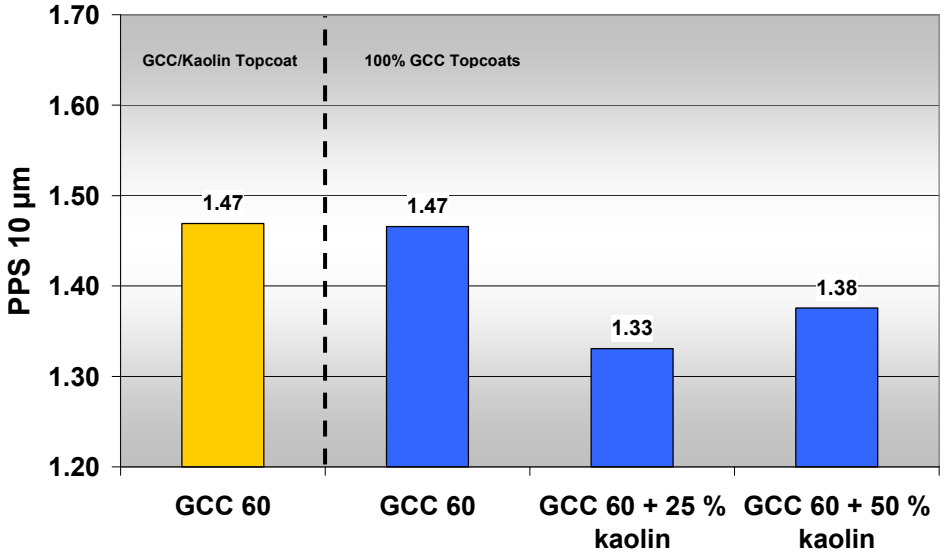
Precoat	Topcoat	Latex Parts
100 % GCC 60	GCC 95 + 15 % UFGK	14
100% GCC 60	100% GCC 99	14
GCC 60 + 25 % kaolin	100% GCC 99	14
GCC 60 + 25 % kaolin	100% GCC 99	11
GCC 60 + 25 % kaolin	100% GCC 99	8
GCC 60 + 50 % kaolin	100% GCC 99	14

Board Properties

GCC/Kaolin Top 100% GCC Top

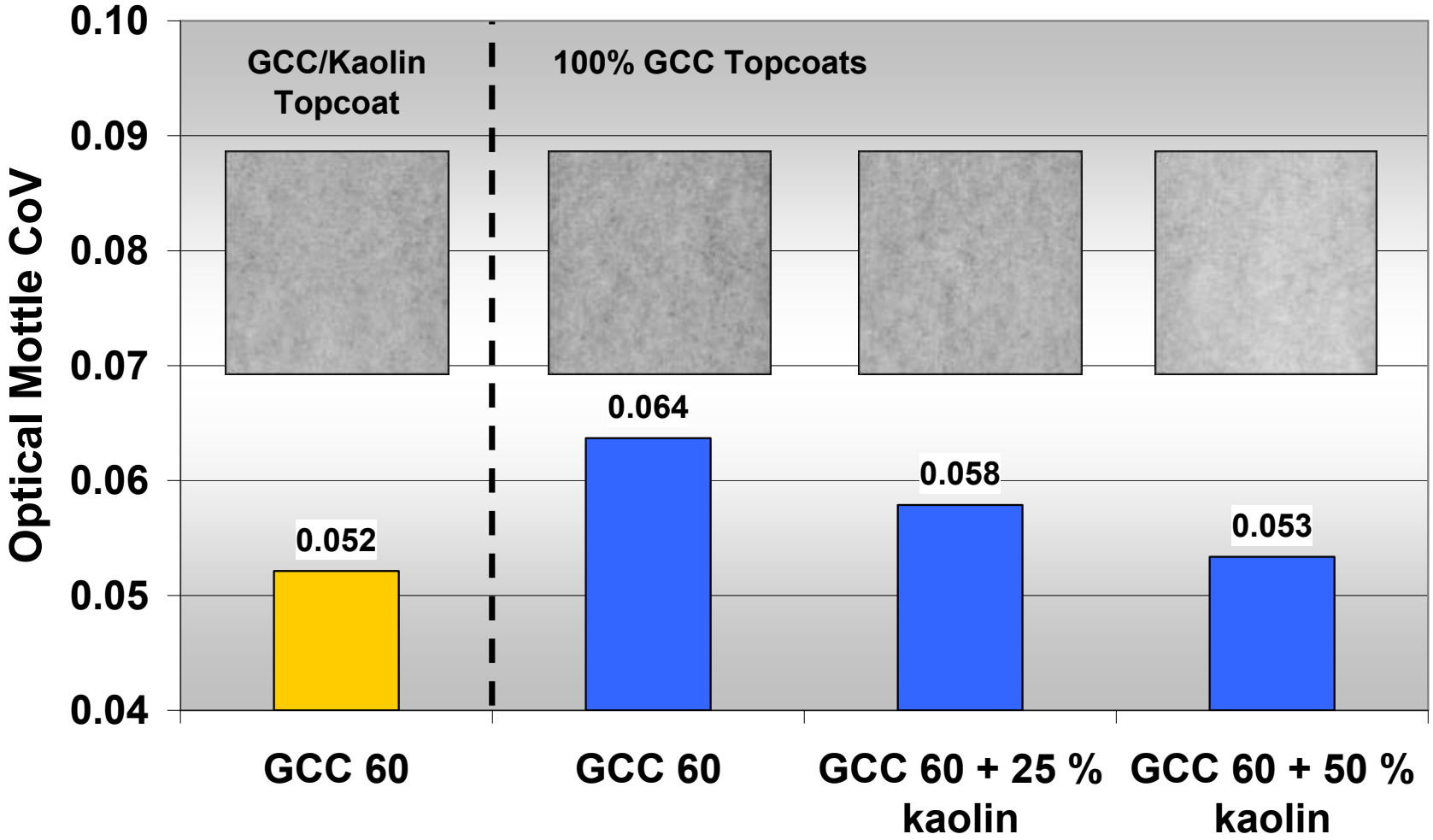






- Removing kaolin from topcoat on this low B'ness baseboard is detrimental to gloss and Brightness when the precoat is 100% GCC
- Adding kaolin to precoat with 100% GCC topcoat improves gloss, PPS and brightness to levels above the reference formulation

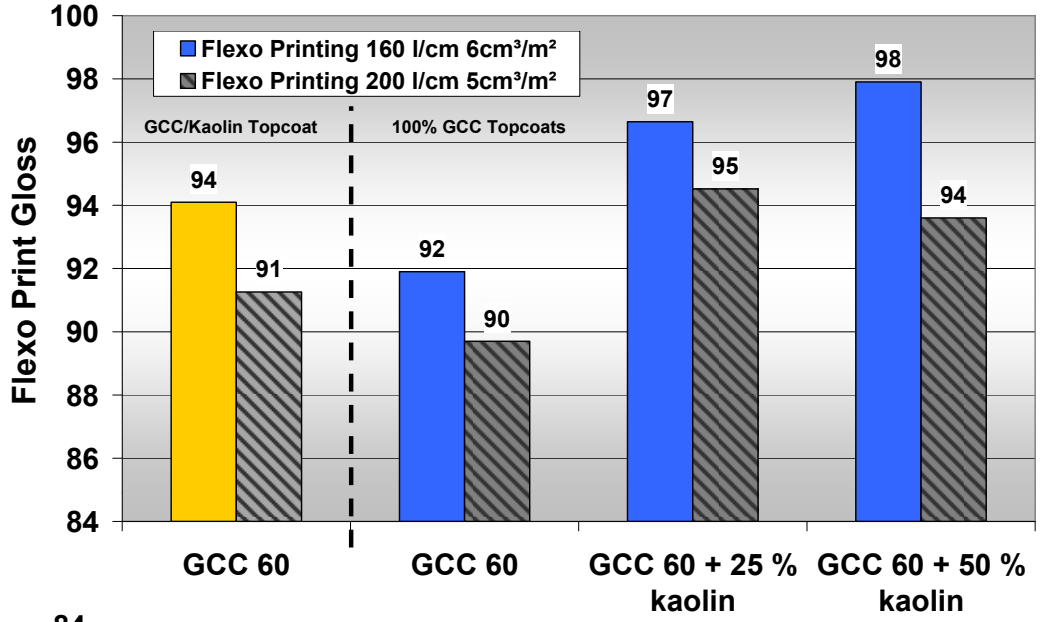
Optical Coverage and Mottle

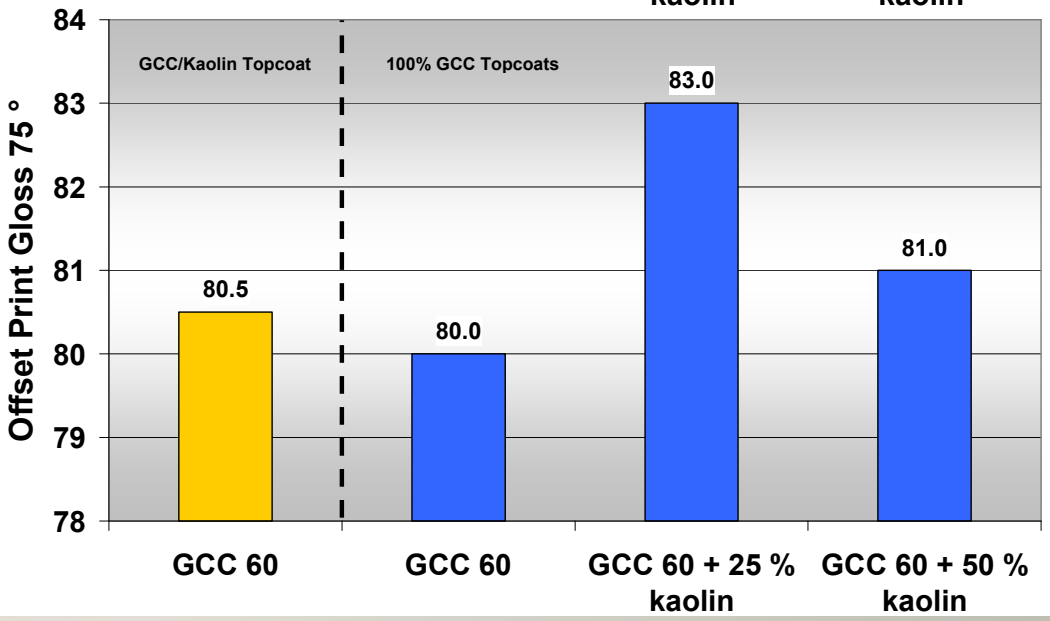


- Results show improved optical coverage when kaolin is present in the coating in line with brightness data
- Kaolin in precoat on balance better than kaolin in topcoat
- Higher level of kaolin in precoat is beneficial

Print Properties

GCC/Kaolin Top 100% GCC Top

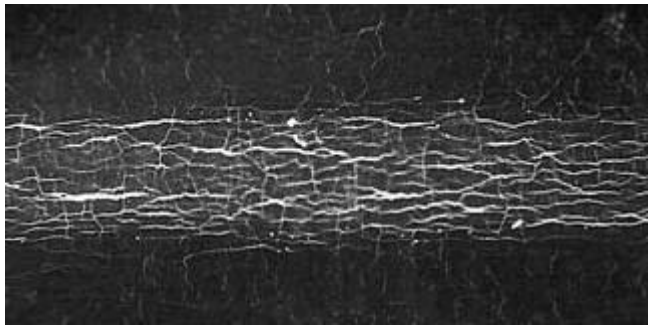




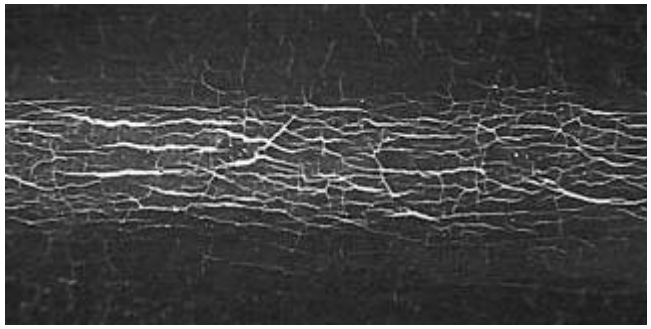
- Boards were printed both flexo (2 conditions) and offset
- Again clear benefits for print gloss with kaolin in the recipe
- Print gloss also clearly better when kaolin is added to the precoat

Cracking Tendency

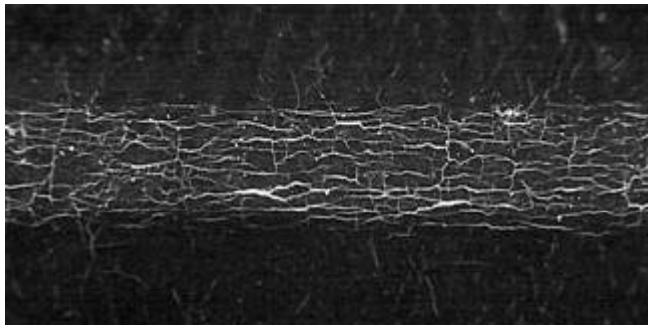
REF PC GCC 60, TC GCC + 15% Kaolin



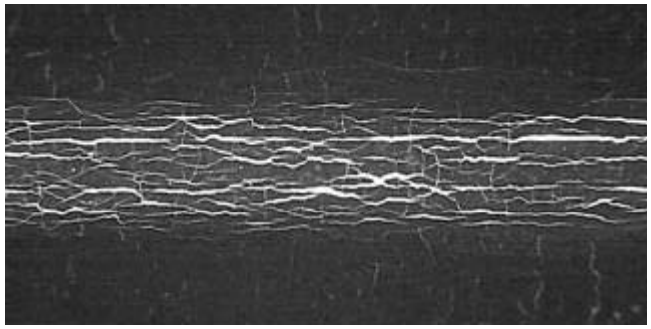
PC GCC+25% Kaolin, TC 100% GCC



PC GCC 60, TC 100% GCC



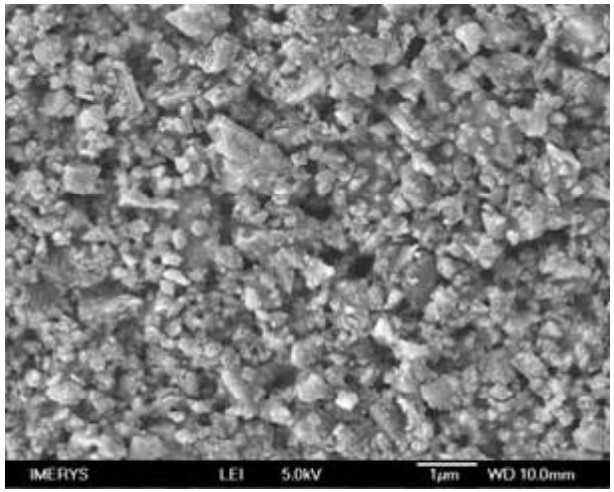
PC GCC+50% Kaolin, TC 100% GCC



- Clear conclusion here is that kaolin in precoat or topcoat increases the severity of the cracks compared to 100% carbonate recipes
- Kaolin in precoat tends to be no worse than kaolin in topcoat for cracking even though kaolin levels are higher
- Further studies exploring reasons for increased cracking with kaolin
  - Relates to stiffness and elastic mismatch

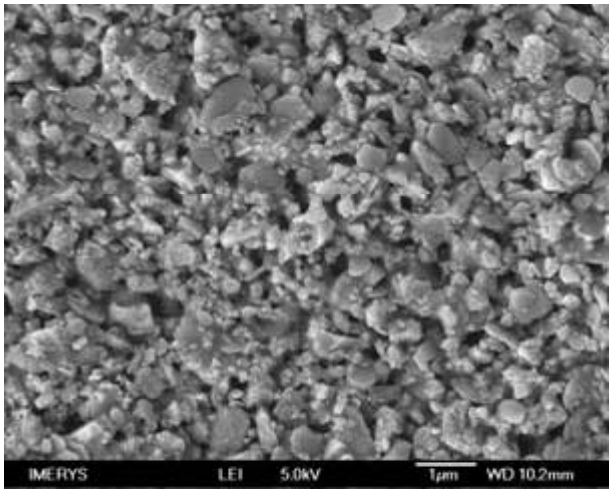
Latex Effects

100% UF GCC Topcoat



14 parts of Latex

GCC95 + 15% UFGK Topcoat



14 parts of Latex

- Visual assessment of topcoats clearly indicates that more latex is present with the 100% GCC topcoats.
- Surface appears more filmy
- Could point towards potential for latex reduction as in CWF, but care need to be paid to cracking tendency

Latex Impact on Board Properties

Precoat	Topcoat	Latex Parts	Board Gloss	PPS 1000 µm	B'ness D65 -UV	Flexo Print Gloss 160 l/cm 6cm³/m²	Flexo Print Gloss 200 l/cm 5cm³/m²	Offset Print Gloss
GCC 60 + 25 % kaolin	99 Grade GCC	14	50.1	1.33	75.6	97	95	83.0
GCC 60 + 25 % kaolin	99 Grade GCC	11	55.6	1.30	76.4	98	96	82.5
GCC 60 + 25 % kaolin	99 Grade GCC	8	60.9	1.22	77.1	98	96	82.5

- If cracking can be managed reducing latex is desirable not only for cost, but also from a performance perspective
- Reducing from 14 to 11 parts latex with kaolin free topcoat gives
  - Improved Sheet Gloss + 5 Units
  - Improved Brightness + 0.8 units
  - Equal print gloss and smoothness
  - No significant impact on porosity

Summary

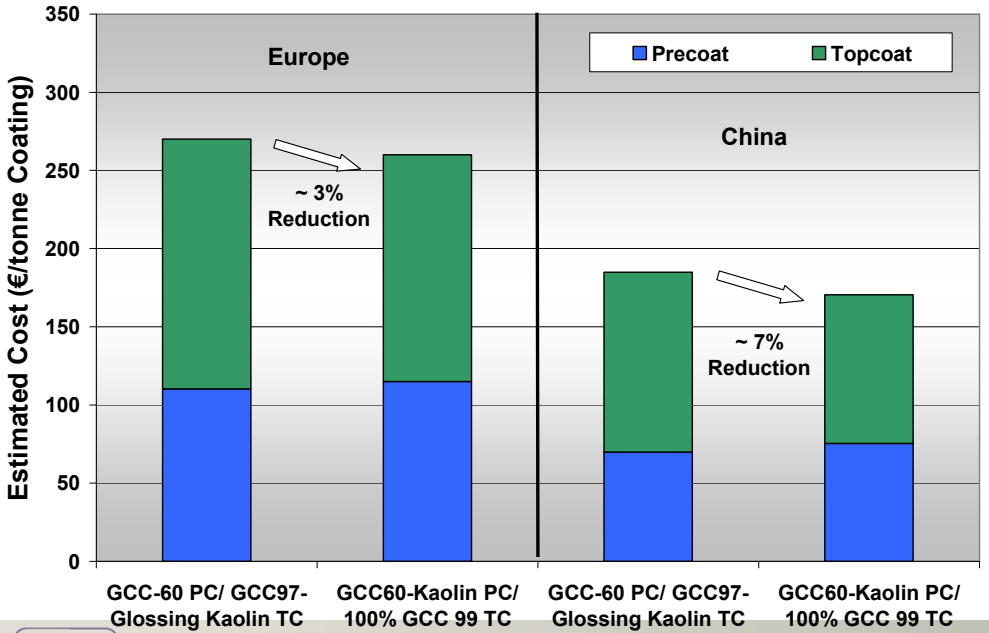
Precoat	Topcoat	Latex	Board Gloss	PPS 1000	Bright-ness	Mottle	Cracking	Print Gloss
GCC 60	GCC95/ UFGK	14	=	=	=	=	=	=
GCC 60	99 Grade GCC	14	-	=	--	-	+	-
GCC 60 + 25 % kaolin	99 Grade GCC	14	+	-	+	=/+	=	+
		11	++	-	++	+	-	+
		8	+++	--	+++	+	--	+
GCC 60 + 50 % kaolin	99 Grade GCC	14	+	-	+++	+	=/-	+

- Similar findings to CWF case but effects larger
- Both pros and cons to the 100% carbonate approach in both coating layers
  - A good concept for whiter smoother base boards
- Kaolin free topcoat with 20-25 parts kaolin in precoat is for the most part technically superior
  - A good concept for less bright and rougher basestocks especially if this accompanied with a modest reduction in topcoat binder 1-2 parts

Overall Summary

Cost Saving Potential

	Conventional		Kaolin Precoat	
	Pre	Top	Pre	Top
Coatweight	12	12	12	12
GCC 60	100		77	
GCC 97		77		
GCC 99				100
Glossing Kaolin		23		
Precoat kaolin			23	
Latex	6	10.5	6	9.5
CMC/PVA		0.75		0.3
Starch	6		6	



- Our estimates of generic European and Chinese pigment/binder costs
- Increased costs from kaolin in precoat offset by potential to reformulate topcoat
- Overall we anticipate a net saving through moving kaolin from topcoat to precoat
- Of course this will vary from mill to mill and region to region.

Conclusions

- Many quality issues in multi-coated applications can still be linked to problems arising in the basepaper or board.
- Achieving good basepaper coverage is therefore essential in maintaining a robust operational window
- This is especially true with today's low kaolin top-coat recipes where base effects are harder to hide
- In this work we have seen that using coarse, high shape kaolin together with GCC is a powerful combination for providing a bulky precoat layer with improved basepaper coverage
  - The result is improved quality and more degrees of freedom for topcoat formulation design to reduce cost
- In today’s fine paper and board markets, we conclude it may now make more sense from a cost-performance standpoint to use the functionality of kaolin in precoating rather than in topcoating
- The unique value of kaolin is in its ability to cover the surface, not in its ability to generate paper gloss, which can be achieved through use of ultrafine carbonates

Thank You!