Georgia Tech Institute of Paper Science and Technology

Starch as a Driver In Papermaking Development

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Advantages of Using Filler in Paper

- Increased filler content in paper will improve paper optical properties
  - Brightness
  - Opacity
  - Print quality
- Increased filler content in paper will reduce papermaking materials costs
  - Pulp price: $250-400/ton
  - Filler cost (clay or PCC): $100-130/ton
- Increase water drainage, drying rate

Potential Problems of Using Filler in Paper

- Effects on wet and dry end operations
  - Retention
  - Water clarification
  - Dusting
- Effects on sheet properties
  - Sheet two-sidedness
  - Reduced paper strength
  - Reduced bulk
  - Linting

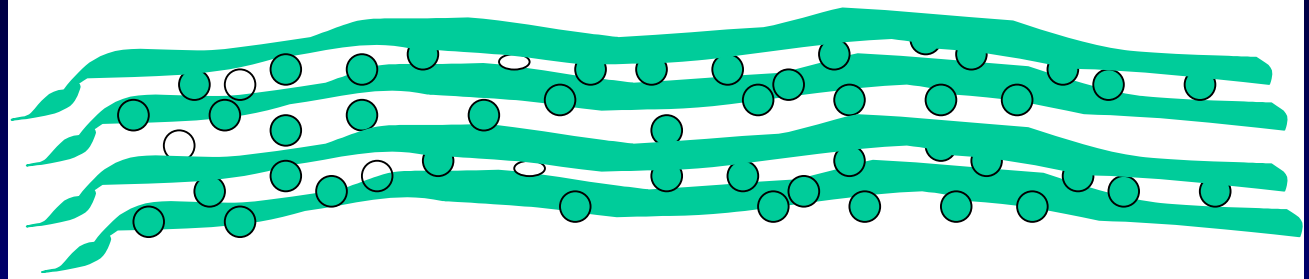
Past Research in Filler Modification

- New filler development
  - Fibril fillers
  - Pretreatment of fillers
- Coating polymer on filler surface
  - Polymers used in the literature are relatively expensive
  - Some polymers can cause environmental problems
  - Effect on paper properties, such as causing unnecessary sizing, increasing recycling difficulty

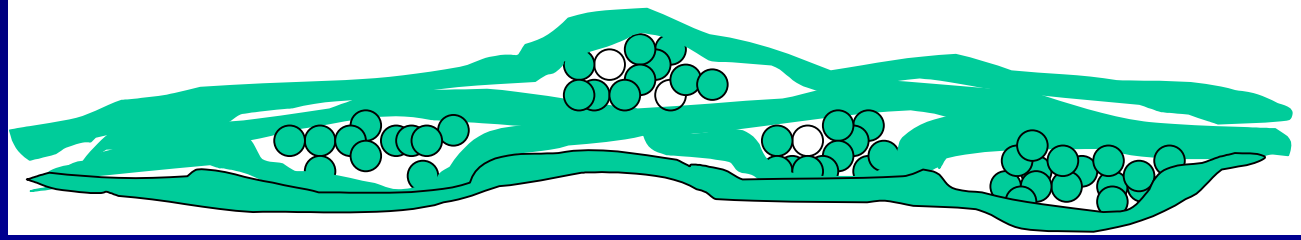
Objective

Develop new bonding fillers to improve existing sheet properties while decreasing fiber costs

Small fiber-fiber contact area: low paper strength

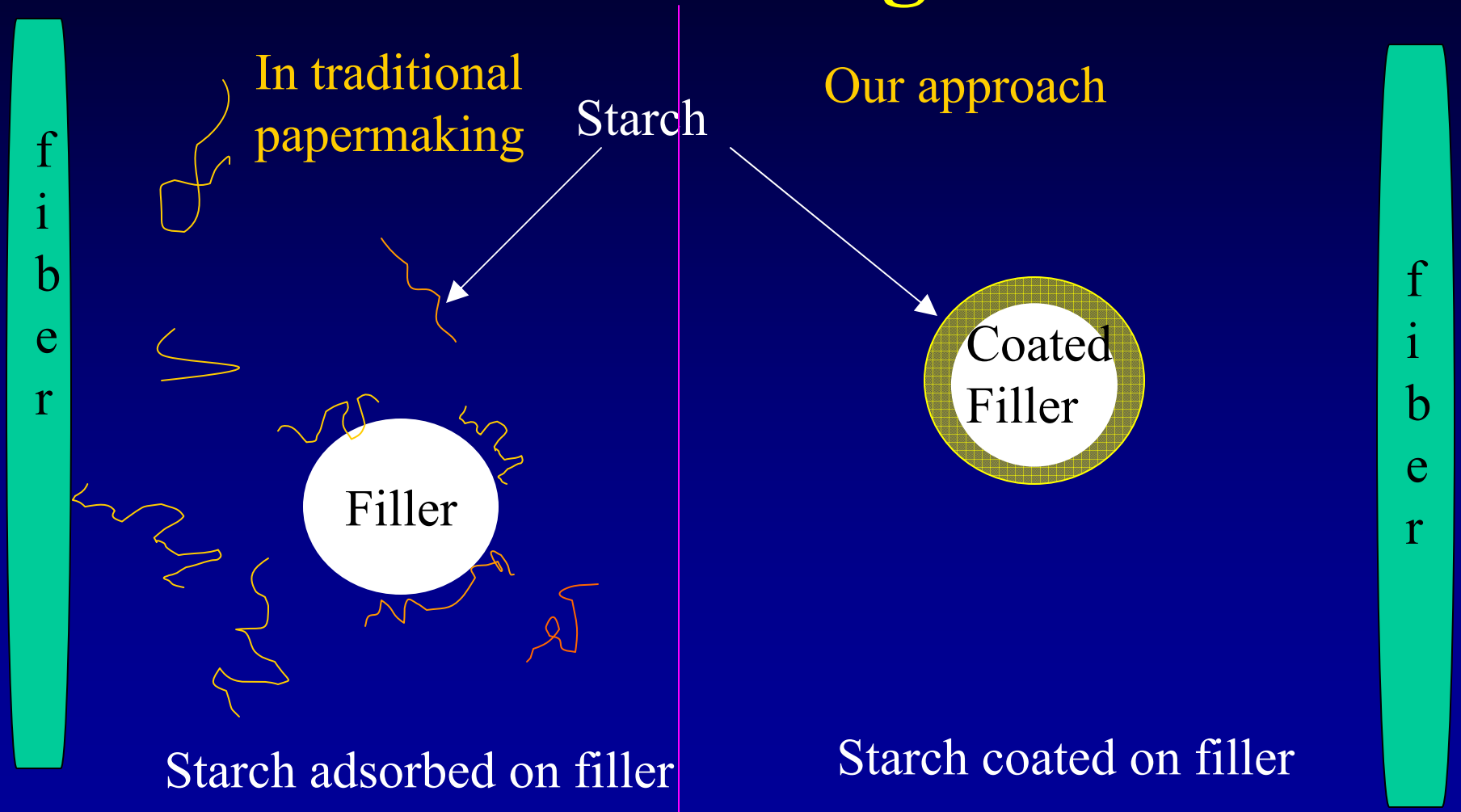


Large fiber-fiber contact area: high paper strength



Conceptual diagram showing impact of filler/ aggregate size on strength

Our Approach: Filler Treatment Using Starch



Approach Using Starch Coating

Filler aggregates coated with starch and with suitable particle size

- Larger particle size: decreased contact area between fiber and filler
- Increased mechanical retention
- Improved bonding (increased bonded area vs. untreated clay)

Filler Treatment with Starch

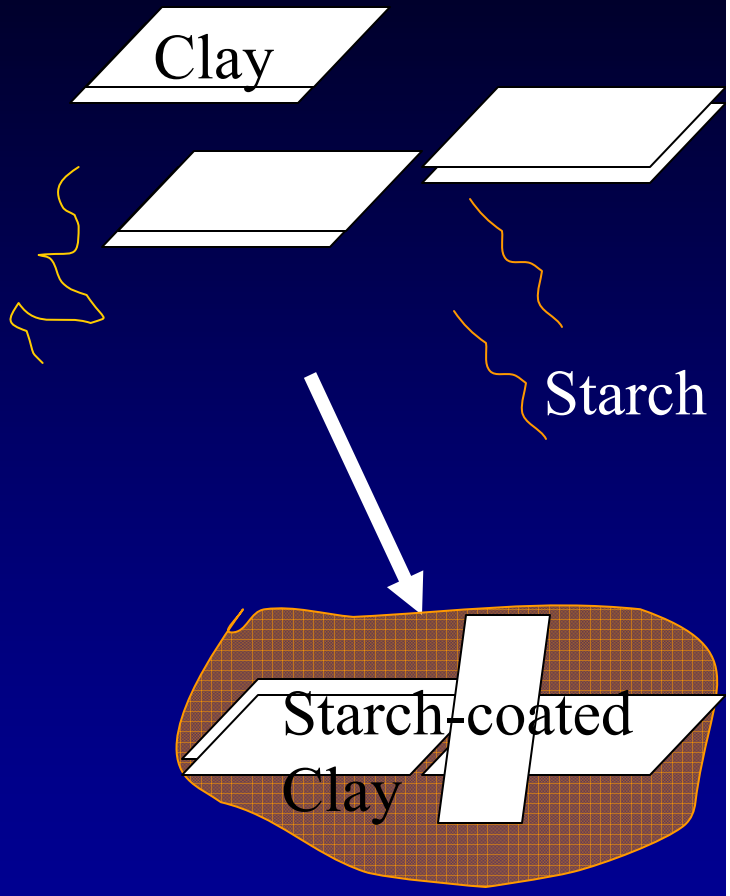
Filler + starch + water

↓ Starch cooked with or without clay

Filler + dissolved starch + water

↓ Dried (feed range of 20-50% solids)

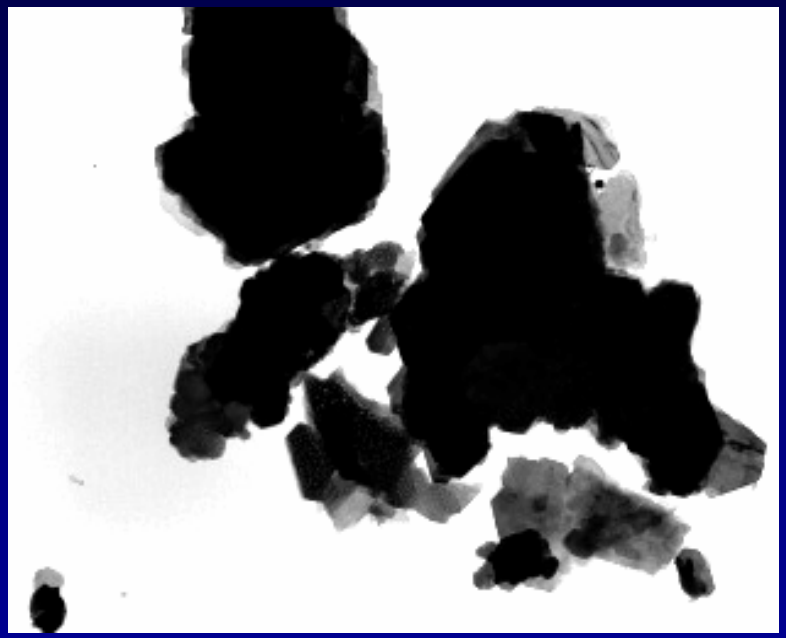
Starch-coated filler



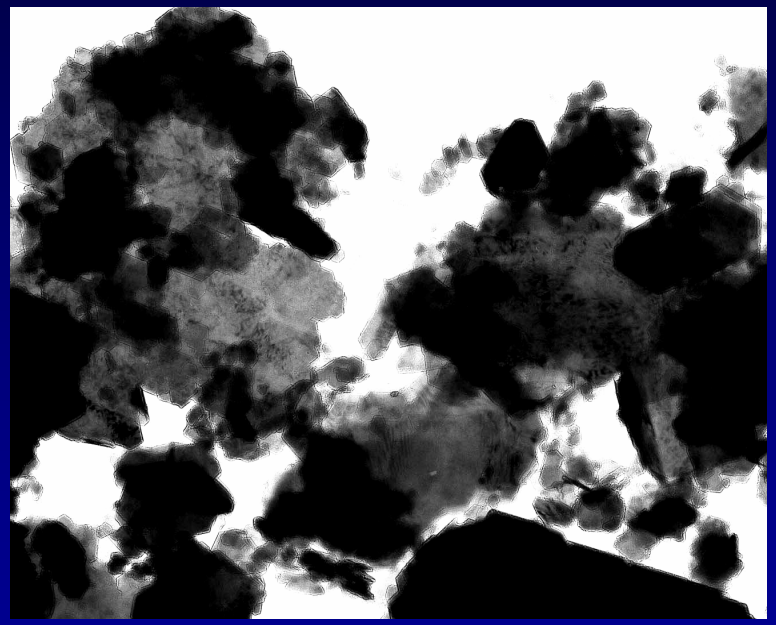
2.5 or 5% starch based on clay
During drying, starch forms network
Clay is encapsulated with starch molecules

20-40 μm; starch coated
Coated starch relatively water-insoluble

Clay Modification

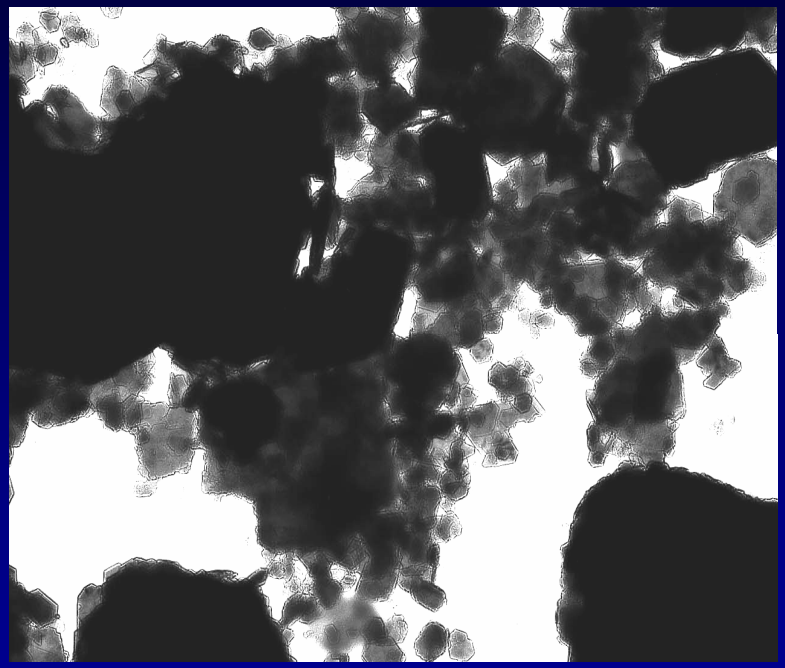


Clay

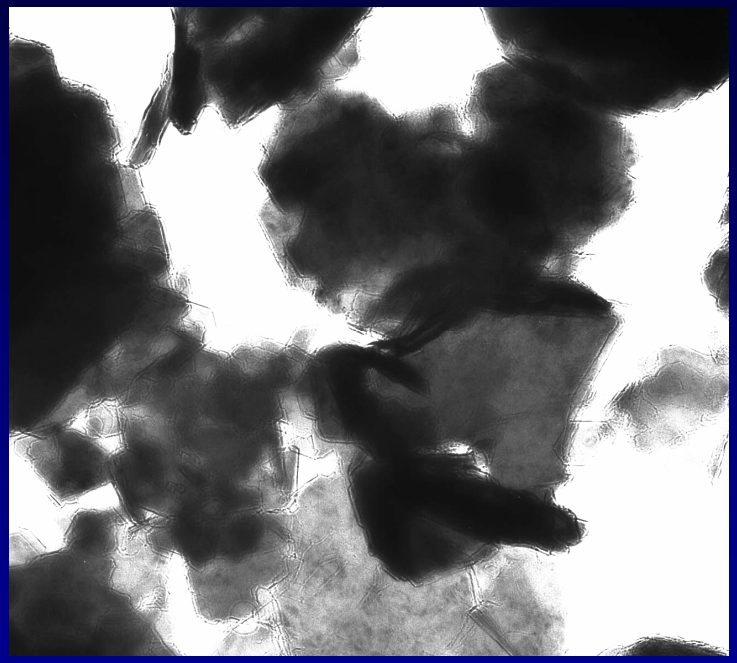


Clay with 5% coated cationic starch

Clay Modification

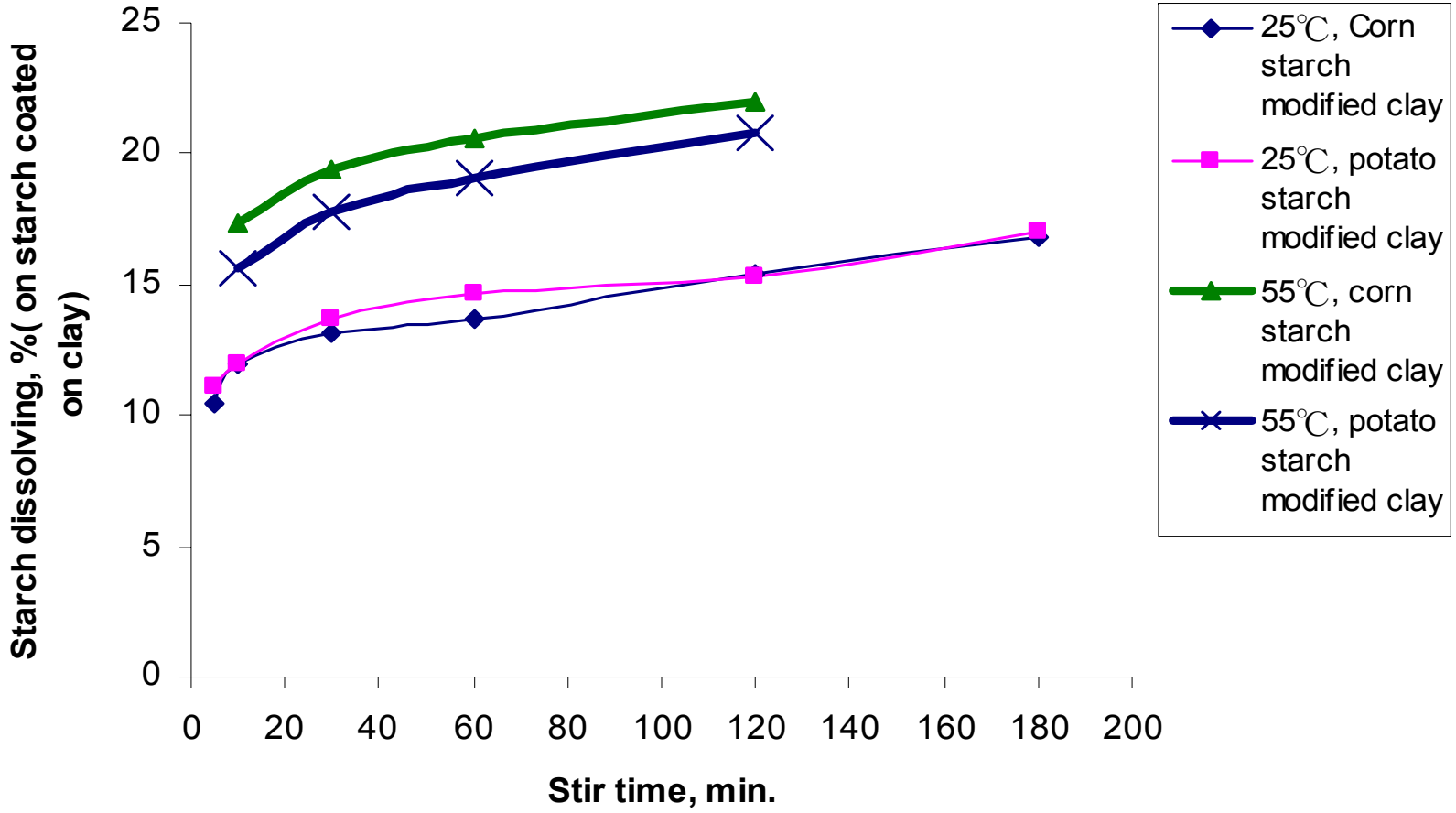


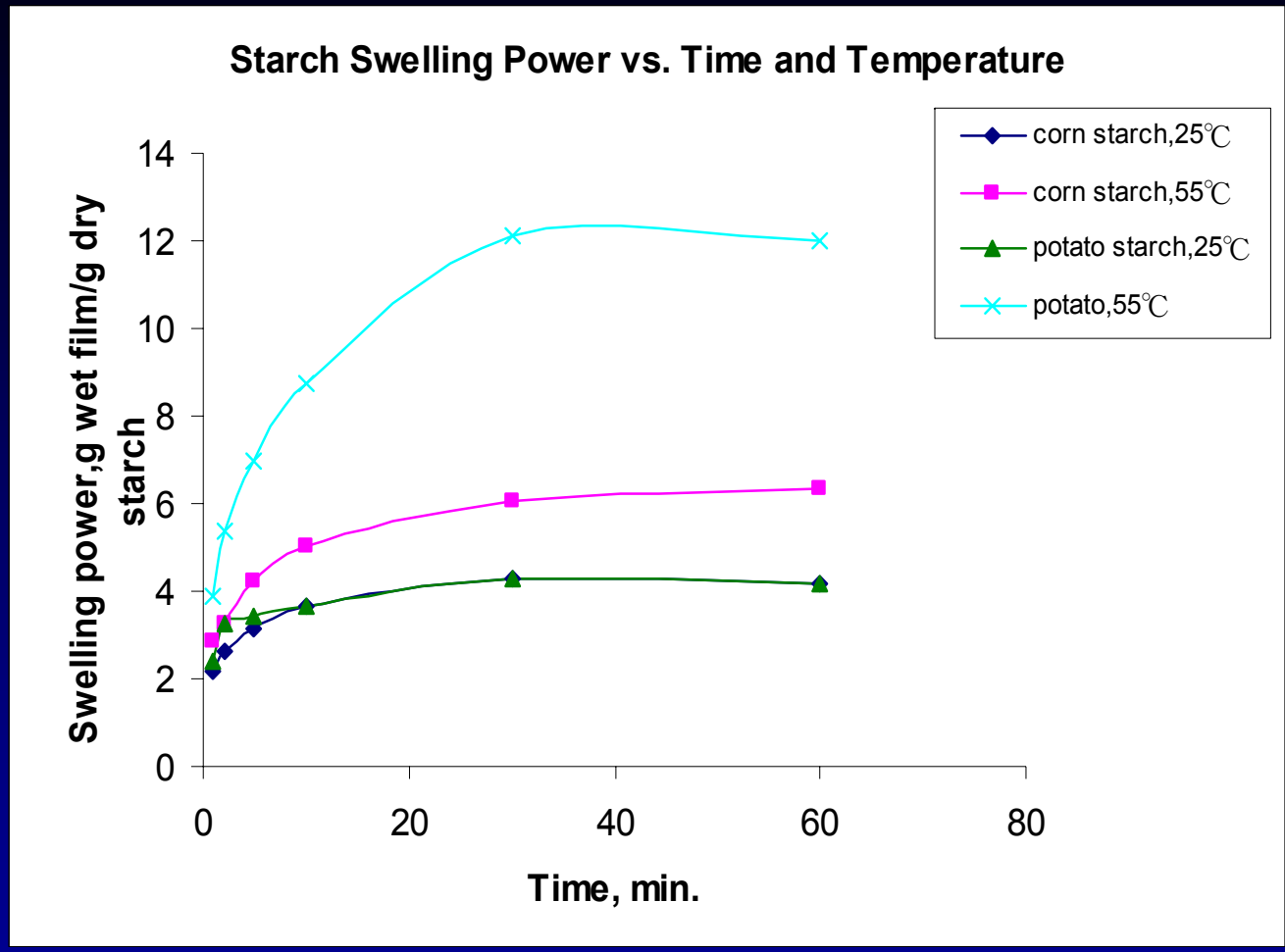
Clay with 5% coated raw potato starch



Clay with 25% coated raw potato starch

Starch Dissolving Profile of 2.5% Starch Modified Clay (stirring speed 1200 rpm, clay consistency 10g/L)

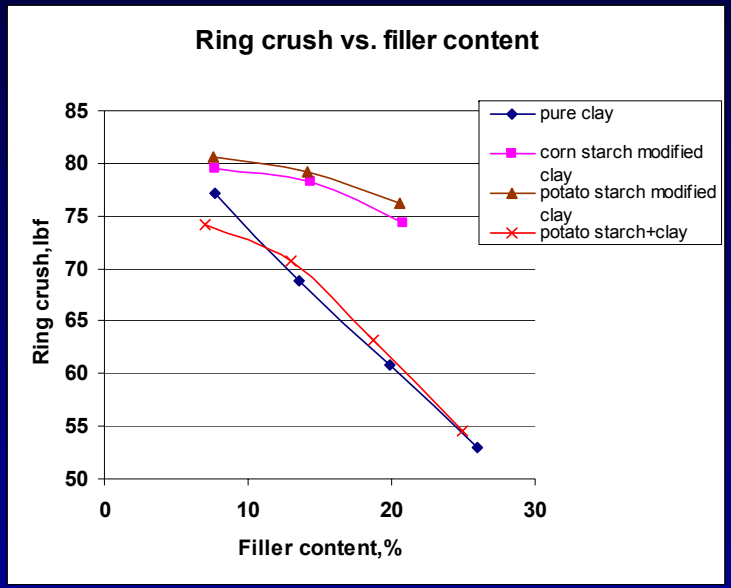




Dried starch absorbs water, swells, deforms
– indication of behavior on clay
which would enhance bonding

Lab Results

- Starch coated and dried on clay surface can increase paper strength significantly (10-15%) vs. use of unmodified clay
  - Ring crush
  - Similar optical properties
- Different starches (corn, potato, cationic starch) gave similar effects
- Starch amount as little as 2.5% of the filler to give significant positive effect

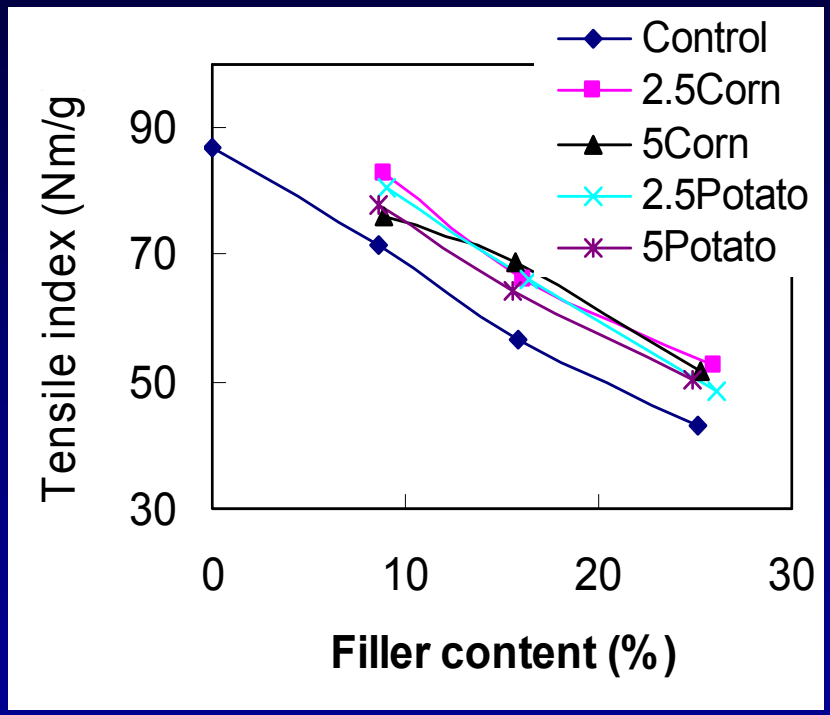


Lab Results (Continued)

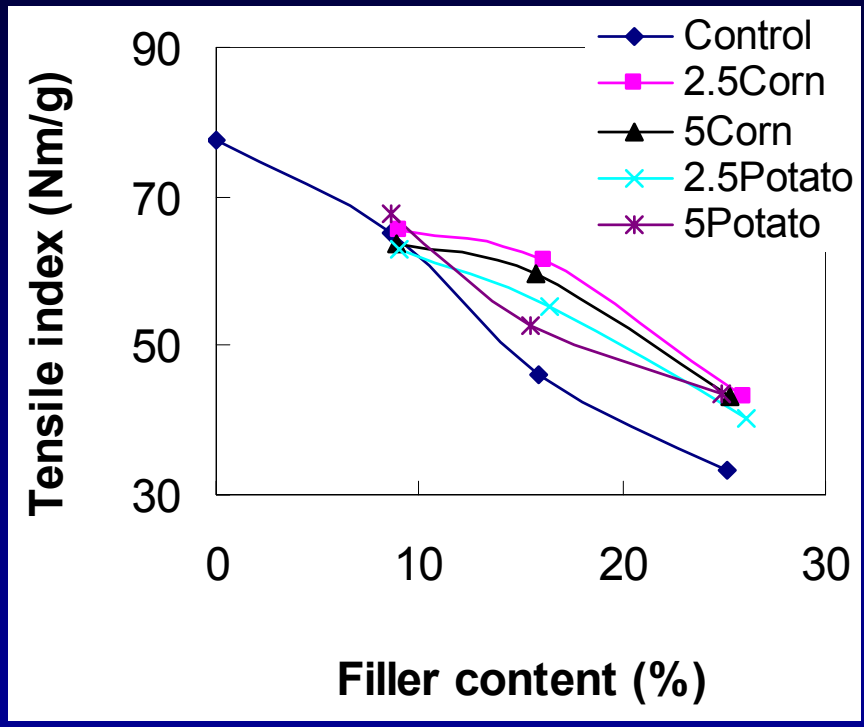
- Confirmed spray-dried starch coated clay has increased paper strength vs. unmodified clay (handsheets)
  - Also bulk and stiffness improvement
  - Modified clay does not reduce clay's ability to increase paper brightness
- Potential to use low cost clay and low grade starch to produce high strength paper/board with high filler content

Laboratory Results

Handsheet Tensile Strength



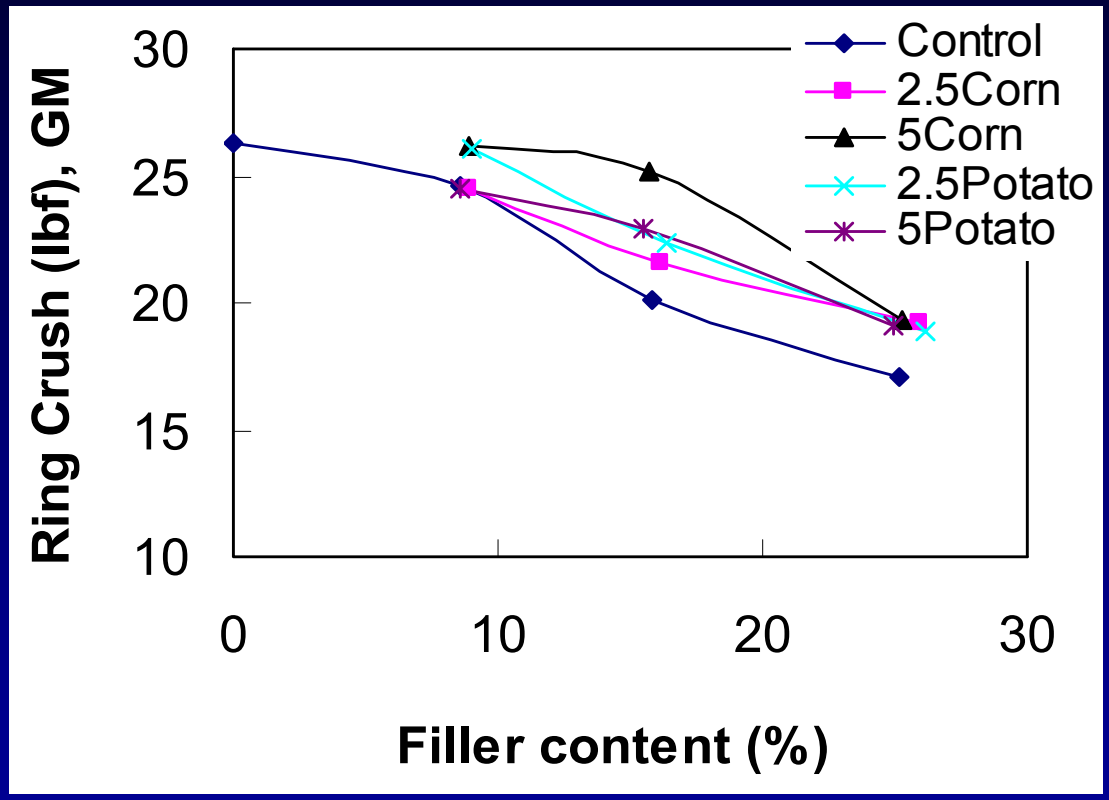
Before Calendering



Calendered

Control: 5% starch based on unmodified clay;
i.e., at 10% clay in sheet: 0.5% starch in sheet (10 lb/t)

Ring Crush, Calendered Handsheets



Can add at least 10-15% modified clay and get same ring crush

Clay Characterization

Clay surface area and particle size

	Clay	2.5% Corn	5% Corn	2.5% Potato	7.5% Potato
Surface area (m^2/g)	10.7	7.9	7.0	8.2	8.3
Particle size (micron)	Percentage less than given particle size				
10	98	95	91	97	96
5	88	88	70	82	84
2	56	43	33	46	52
1	35	22	16	24	31
.5	19	9	6	10	14
.25	8	3	2	3	5
.2	6	2	1	2	3

Modified clays: lower surface area, larger particle size

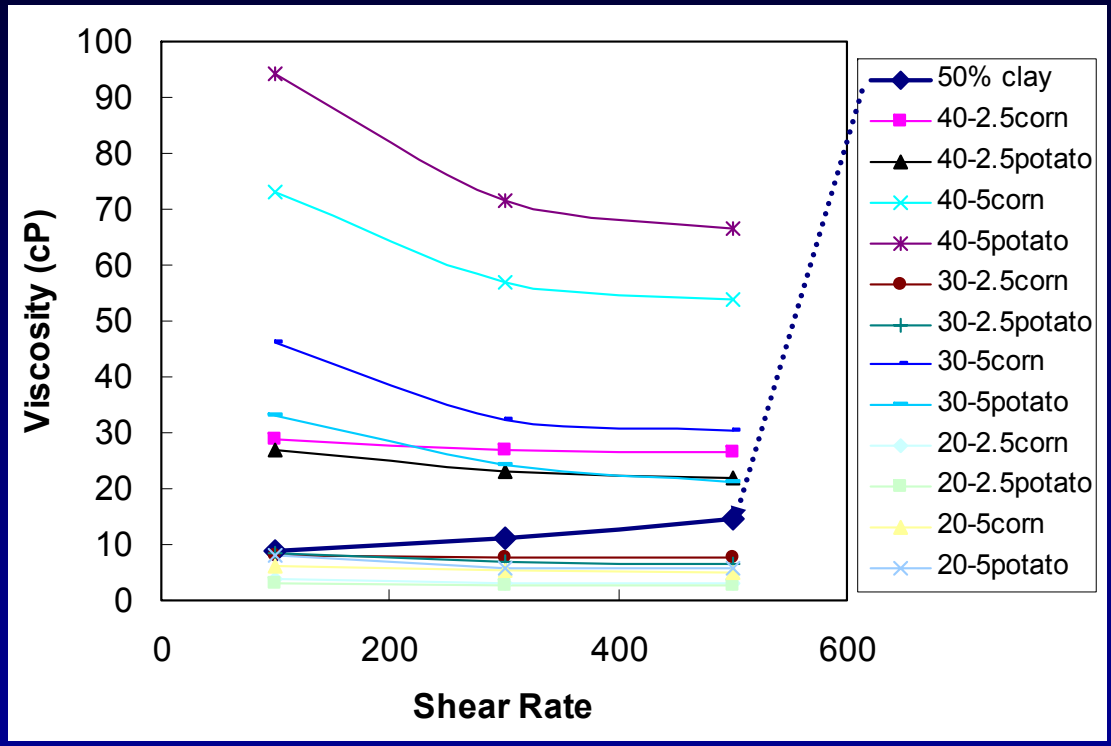
Pilot Results

- Modified clay filler produced using pilot spray dryer at IPST, at IMERYS
- Pilot mill trial at Herty Foundation with spray dried clay from Imerys spray dryer
- Confirmed scale-up
  - Sheet properties
  - Dewatering improvement with clay addition

Spray Dryer Evaluation

Clay Viscosity

- Shear viscosity measured for control clay and modified clay
  - To assess potential for spray drying
  - Control: 50% solids unmodified clay
  - Modified clay: 20-50% solids range investigated



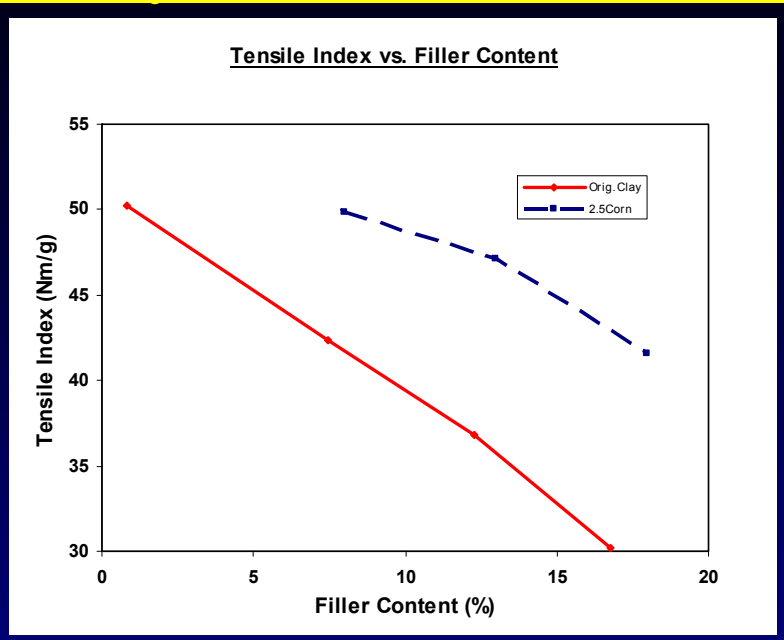
Spray Dryer Evaluation

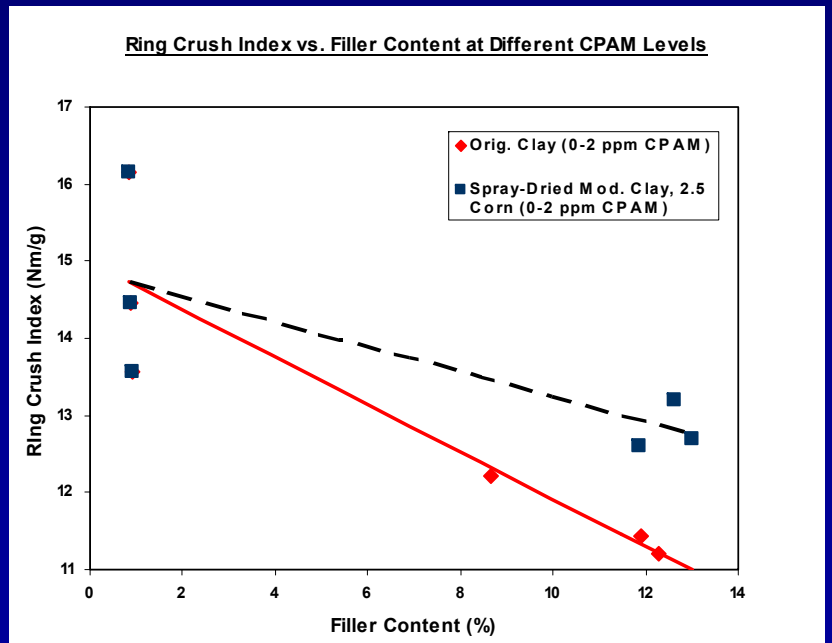
Sample	Feed rate (ml/min)	Gas Temp (oC)		Mass yield (%)
		Inlet	Outlet	
20% Clay	24.5	210	120	72.0
20-2.5Corn	22.3	210	120	99.0
20-5Corn	25.3	210	120	88.1
20-2.5Potato	35.6	210	120	74.0
20-5Potato	24.6	210	120	82.1
50% Clay	27.5	210	120	79.7
30-2.5Corn	25.3	210	120	96.9
35-2.5Corn	17.3	210	120	95.1
40-2.5Corn	20.8	210	120	97.8
45-2.5Corn	7.5	210	120	92.6

- Results: modified clay can be spray dried up to 40-45% clay

Spray – Dried Starch-Coated Clay – Handsheet Trials

- Modified Clay
  - IMERYS (Atlanta, GA)
  - Modified clay coated with precooked 2.5% corn starch via spray drying of 40% clay slurry
  - Particle size (light scattering, in suspension) increased with modified clay vs.conventional clay
- Furnish
  - SW kraft pulp, kappa 105, Inland
  - Pulp was beaten to C.S.F. 350 ml
- Handsheets
  - TAPPI method, 180 g/m^2, CPAM retention aid.

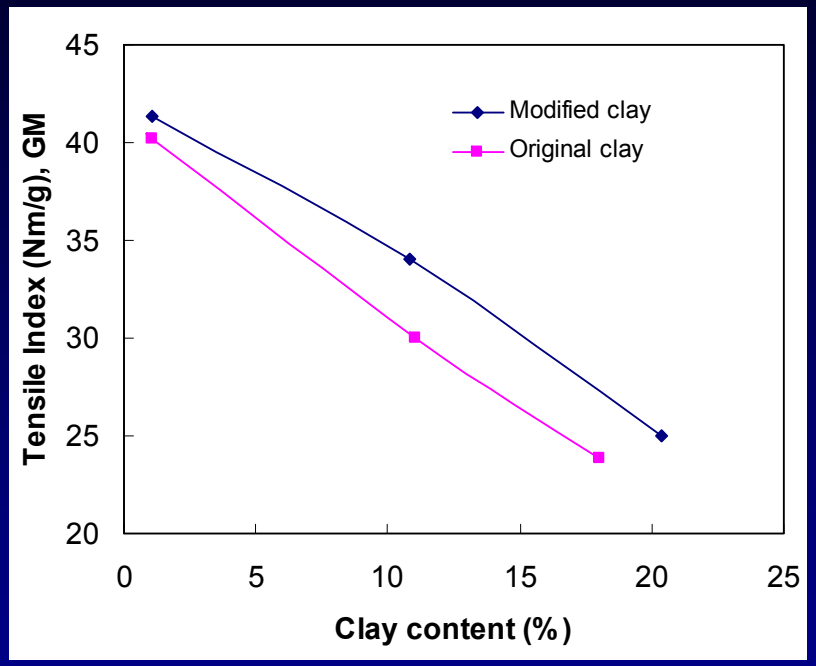


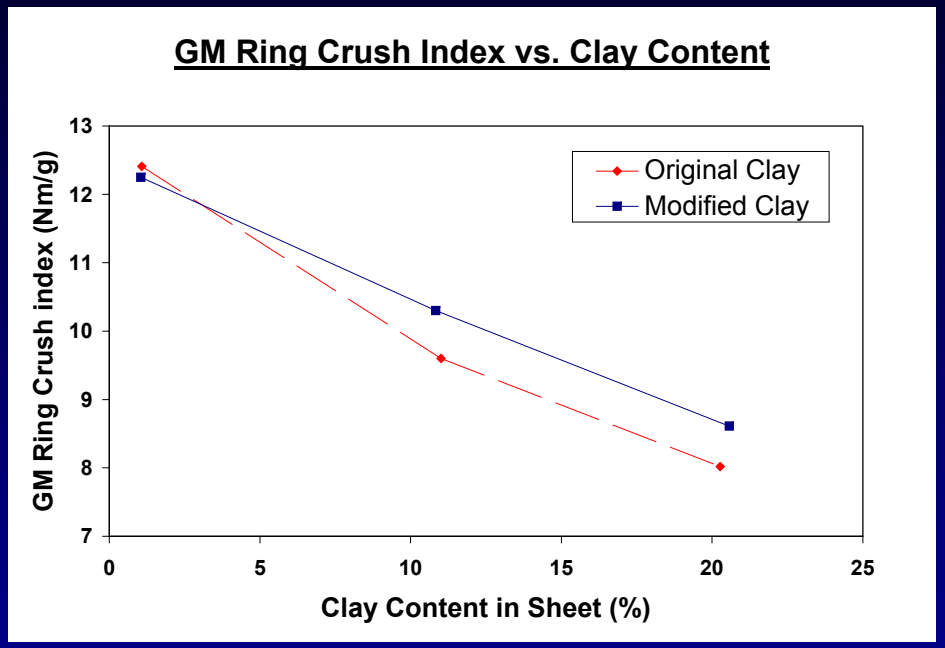


Spray-Dried Starch-Coated Clay-Herty Pilot Trial

	CONTROL (No clay)	ORIGINAL CLAY	STARCH COATED CLAY
Filler	None	Stnd clay (High AR) • 10 % • 20 %	Mod. Clay (1.8% starch; spray dried@20% solids) • 10 % • 20 %
Furnish	Reslushed liner furnish (IP), mixed SW/HW, CSF 500-550 ml		
PM	Single ply; BW 170 g/m^2 ; 75 fpm		
Chemicals (pH 6-7)	Corn starch	Corn starch (2.5%) RA: CPAM (Percol 175) 1 ppm	RA: CPAM

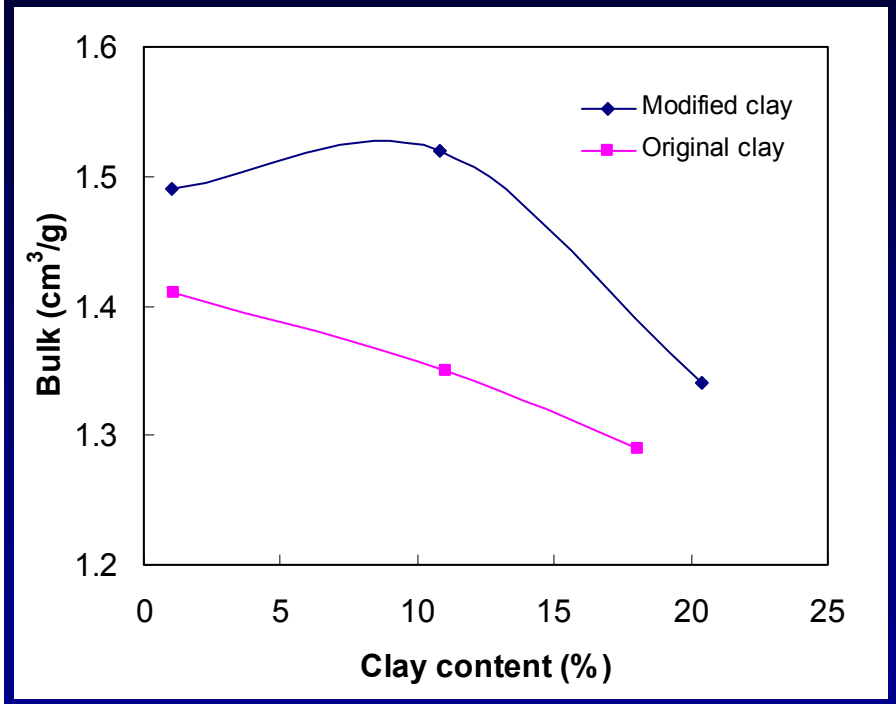
Spray-Dried Starch-Coated Clay- Herty Pilot Trial

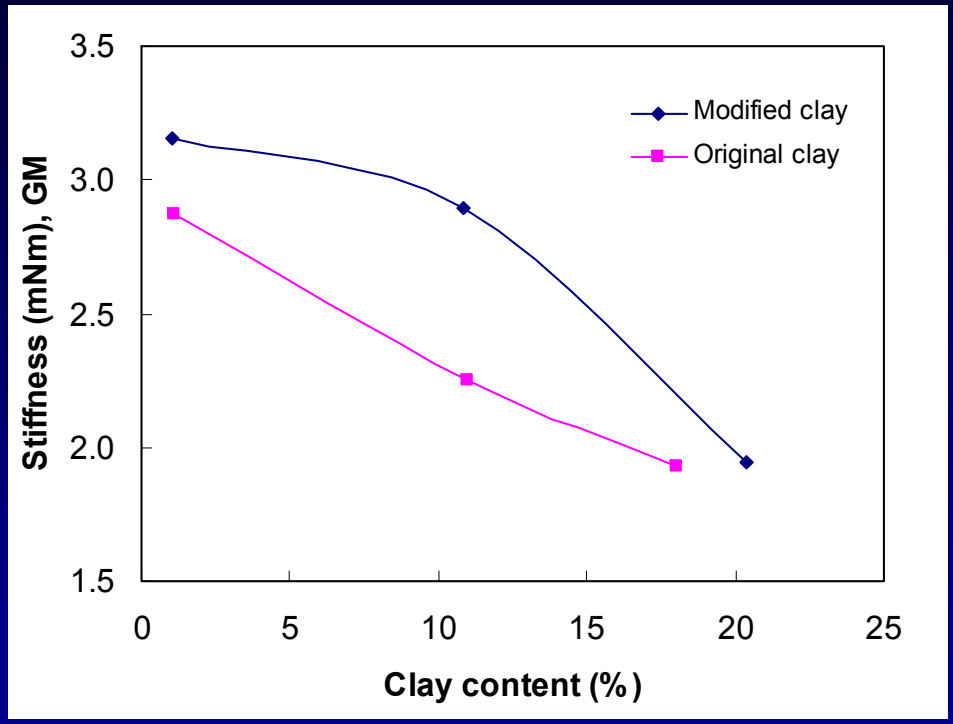




Over 10% increase in tensile and ring crush with modified vs. conventional clay
Decrease in strength vs. unfilled control (starch content less than target)

Herty Pilot Trial : Bulk, Stiffness

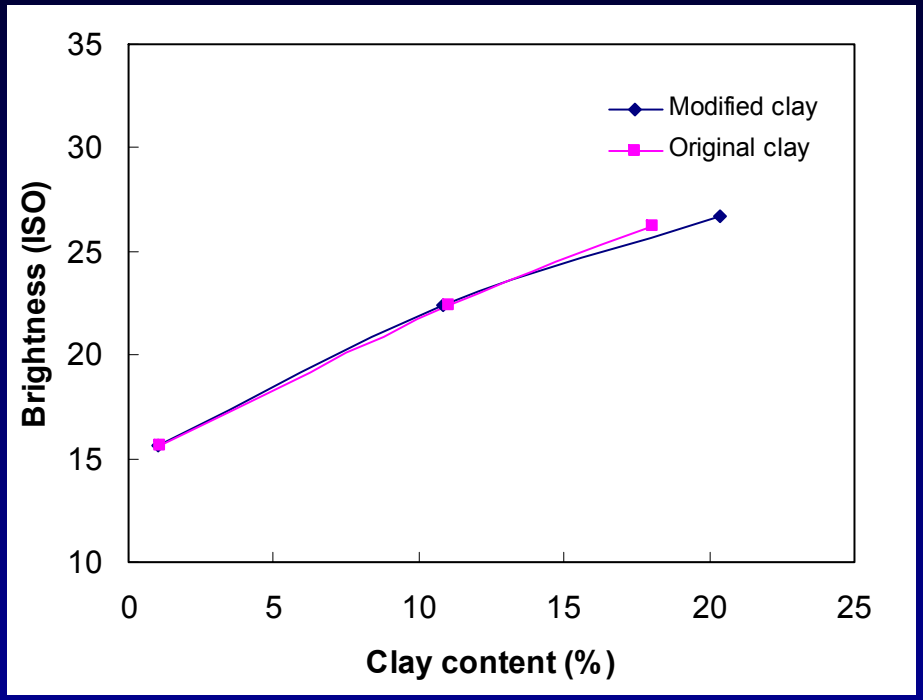




Bulk maintained at 10% modified clay content

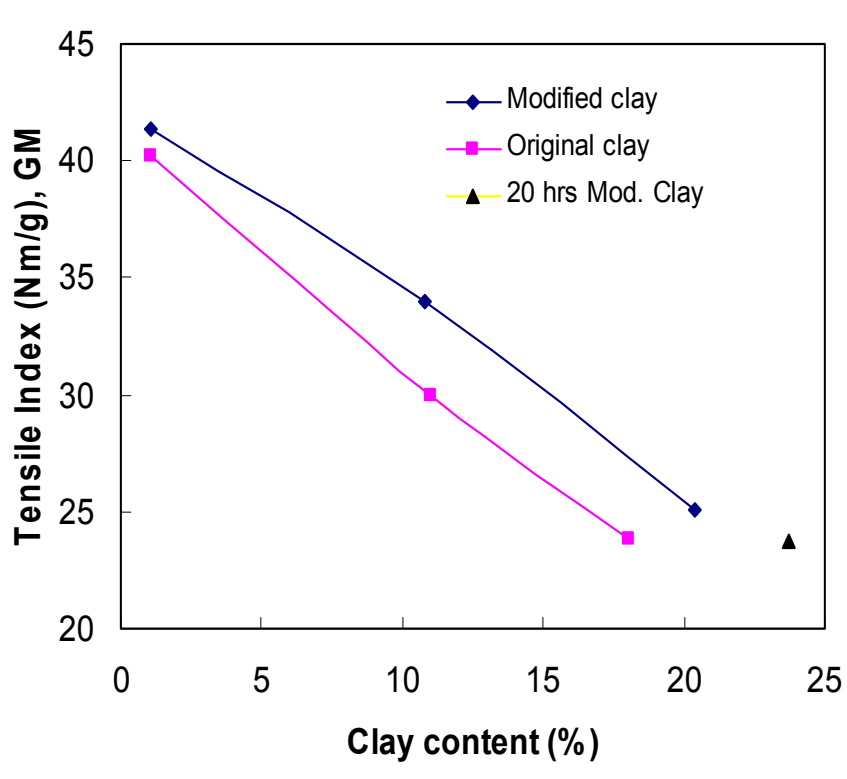
Stiffness reduced only slightly at 10% modified clay content; stiffness increases with bonding, but is more sensitive to sheet thickness (Moberg)

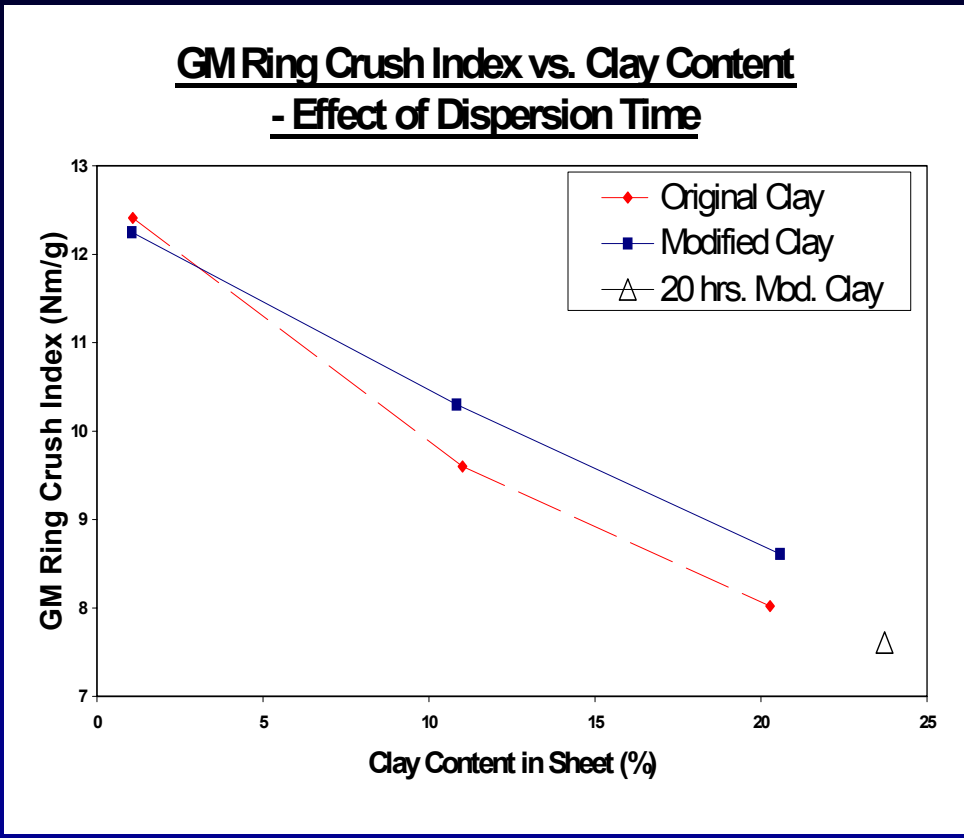
Brightness



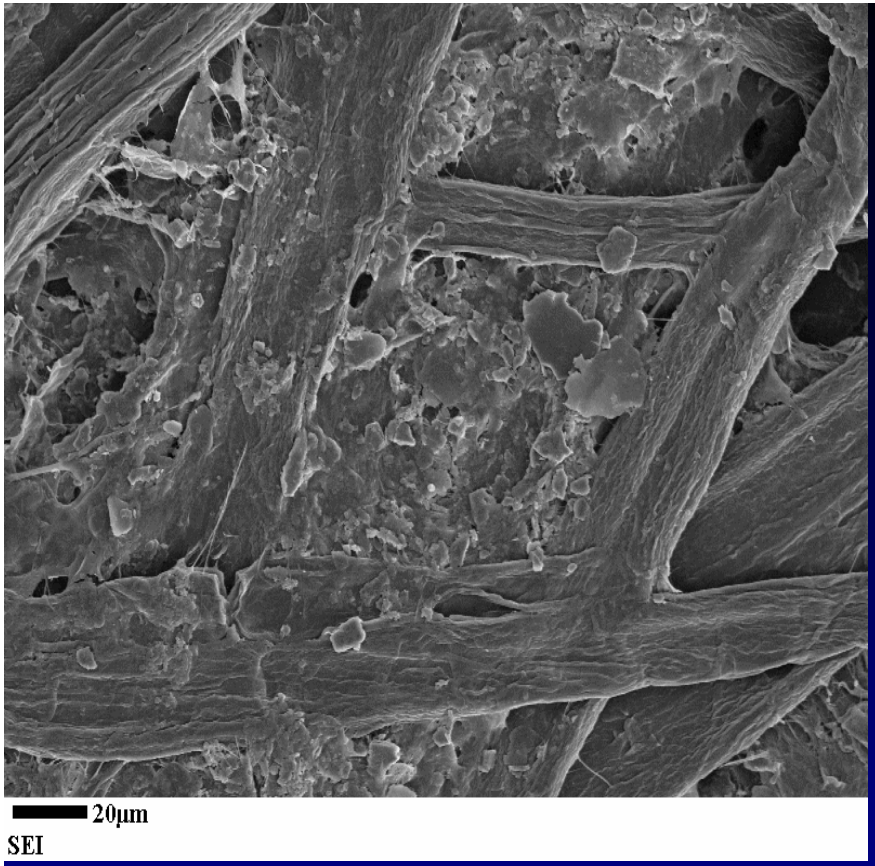
Similar brightness increase with modified and conventional clay

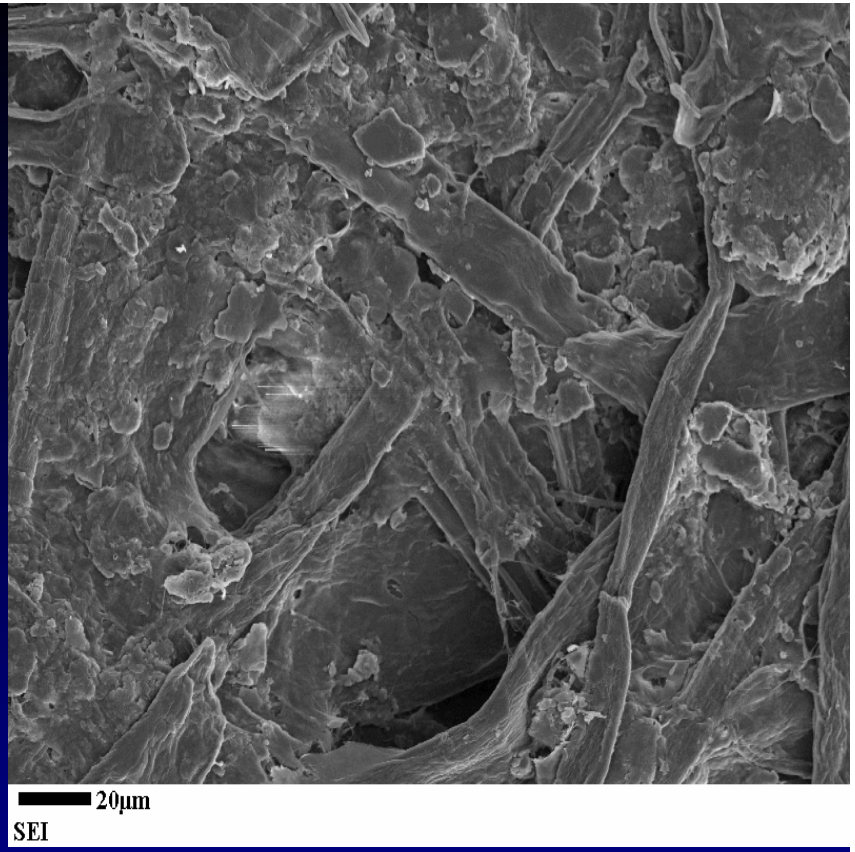
Effect of Dispersion Time





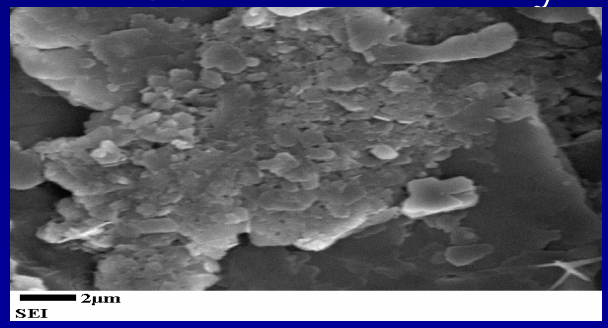
Long dispersion time had no effect on tensile, but possible effect on ring crush



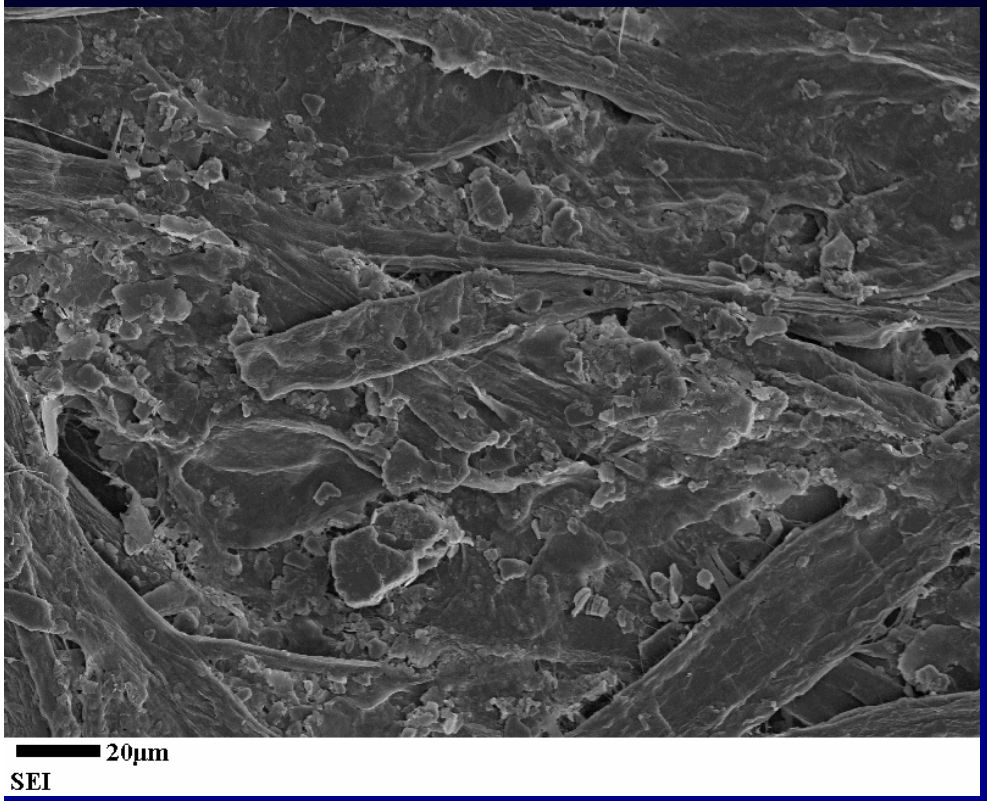


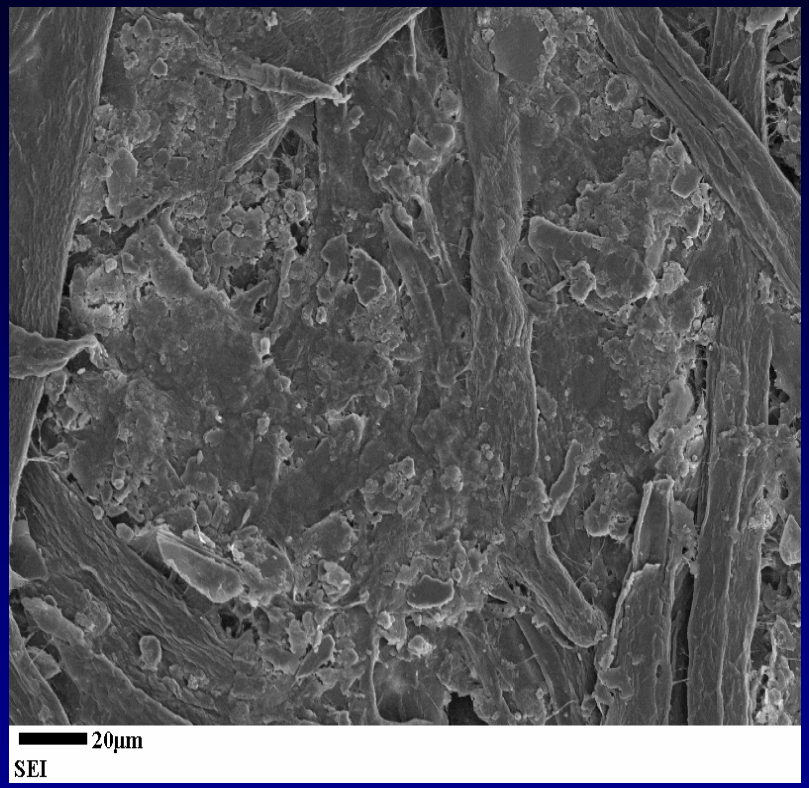
10% original clay

10% modified clay



Consistent with particle size measurements: IPST (laser- orig. clay: 9.5 µm, modified clay: 38.2 µm); Imerys (Sedigaph: mod. clay slightly coarser)

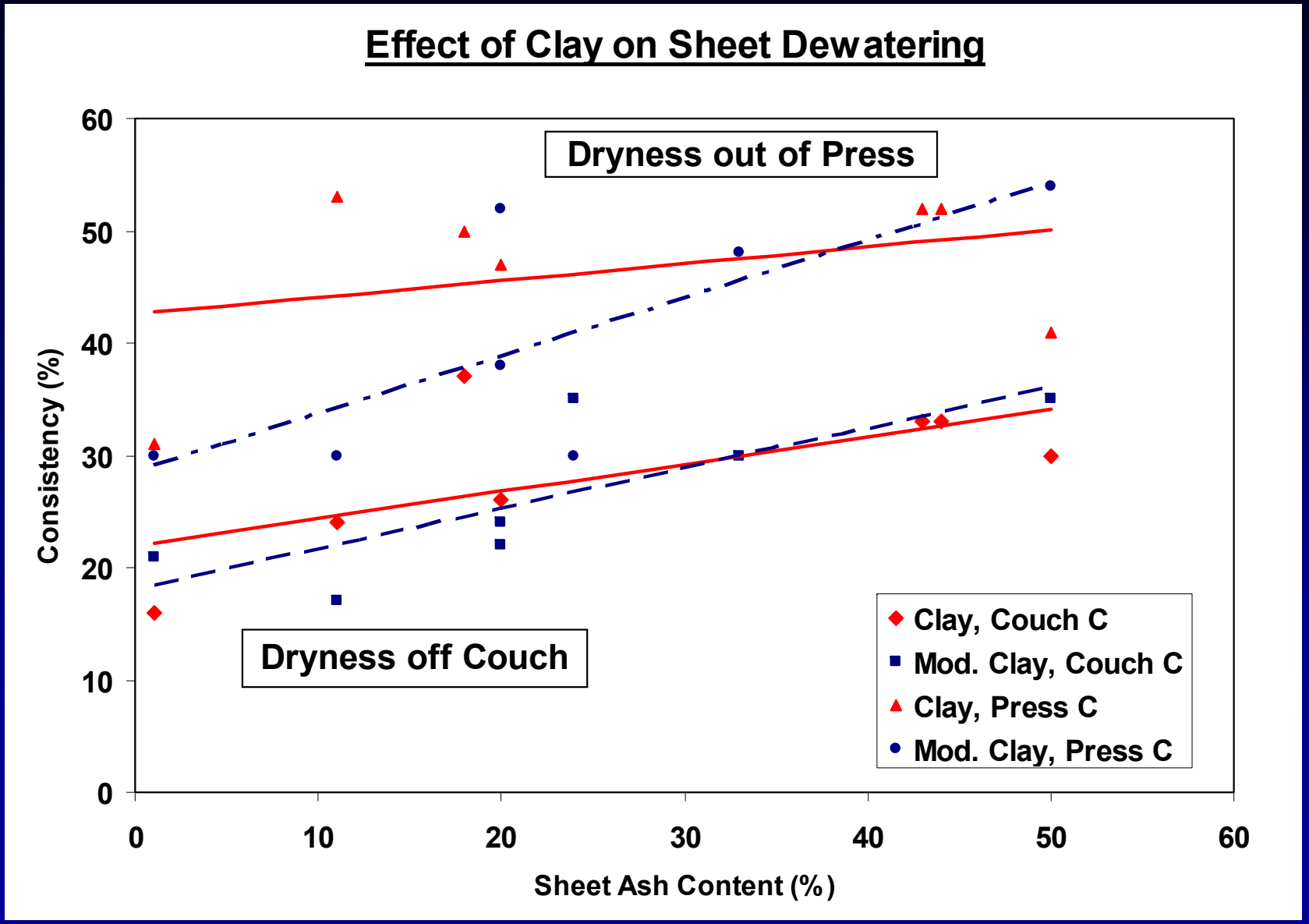




20% unmodified clay

20% modified clay

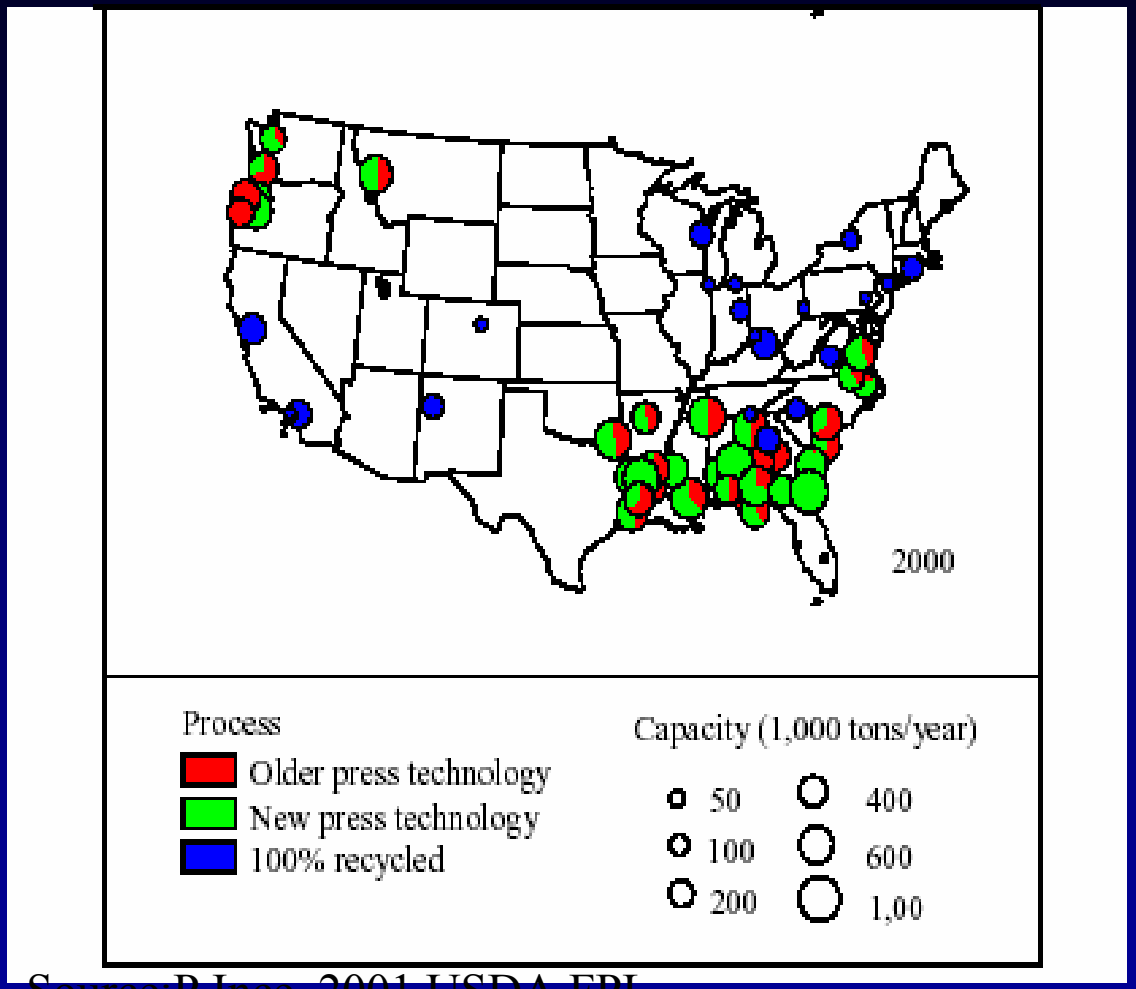
Effect of Clay on Dewatering



Significant effect of clay or modified clay on dewatering.

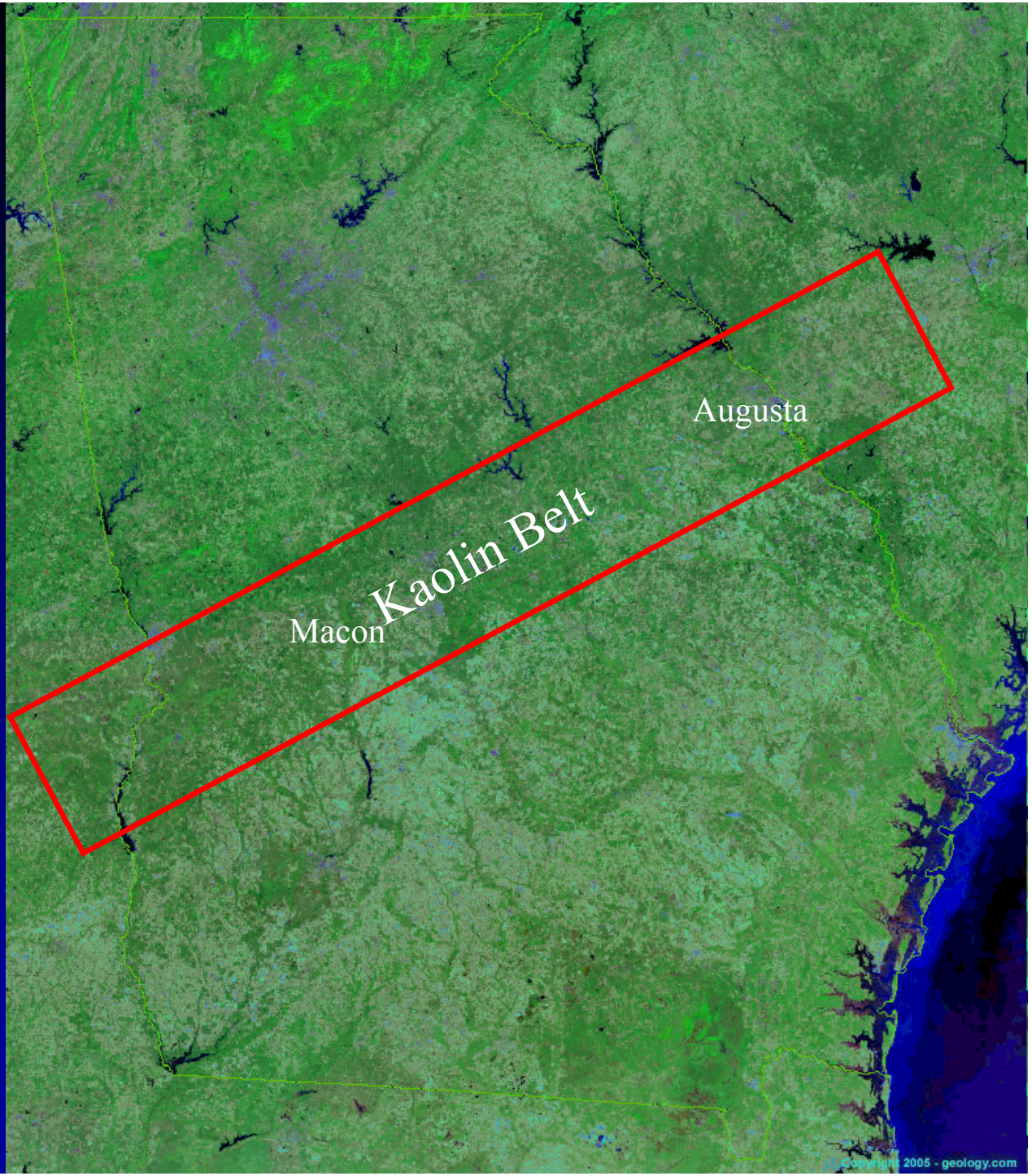
Linerboard Capacities

Linerboard capacities in USA are close to Kaolin deposits in SE



Source:P Ince, 2001 USDA FPL

Logistics Unique to SE USA Paper Industry



Summary

- Modified filler platform developed
- Potential to use low cost clay and low grade starch to produce high strength paper/board with high filler content
  - Decreased fiber and processing costs
- Evaluating options for modified clay production
  - Lower cost clay sources and processing
  - Process development and scale up of modified filler
  - Support of further pilot filler production and applications testing

Acknowledgement

- Georgia TIP3 Program for financial support
- Imerys