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SOIL DEVELOPMENT AND FERTILITY IN AN ALLUVIAL CHRONOSEQUENCE, SOUTHWESTERN SACRAMENTO VALLEY

Background

- Properties change as a soil becomes progressively older
  - Mineral weathering → desilication of primary minerals
  - Changes in minerology effect on soil fertility in regard to nutrient avilability
- Monitoring one soil over the course of its "life" → not feasible
  - Substitution of space for time

Project Goals:

- To understand the dynamics at play as soils weather in a chronosequence of soils derived from Putah Creek alluvium:
  - Changes in mineralogy
  - Soil texture
  - Cation exchange capacity
  - Nutrient abundance

To Achieve This:

- 3 soils sampled in the chronosequence
  - Yolo Series – <2,000 y.o.
  - Hillgate Series – 75,000-192,000 y.o.
  - Corning Series – 200,000-400,000 y.o.
- Each soil described in the field
- Sampled by morphological horizon to a depth ~60 cm (average rooting depth of most crops)

Procedures:

- Oven drying to determine AD H_2O content
- Particle size analysis
  - OM oxidation
  - Sand separation by wet-sieving through a 300 mesh sieve
  - Silt/Clay flocculation using NaCl
  - Clay content dertemination via extraction of an aliquot

Procedures Continued:

- Fractionation – silt/clay separation by centrifugation
- Oriented clay mounts for XRD
  - 3 slides/soil horizon
  - Clay treated with:
    - KCl
      - Post-XRD: KCl slides heated to:
        - 350° C – 2 hrs.
        - 550° C – 2 hrs.
    - $MgCl_2$
    - $MgCl_2$ + 1:1 glycerol and water mix

Procedures Continued:

- CEC_7
  - Mechanical vacuum extraction by NH_4Oac
    - Samples flooded with NH_4^+
    - washed with ethanol
    - Sorbed NH_4^+ was displaced with Na
      - displaced ammonium was measured colorimetrically
  - NH_4Oac extracts → atomic absorption & flame photometry determined extractable:
    - Ca^{2+}, Mg^{2+}, Na^+, and K^+
- %BS

Physical Characteristics

SOIL	DEPTH	COLOR				TEXTURE	SAND	SILT	CLAY	ROCK	AIR DRY	CONSISTENCE	
			H	V	C		%	%	%	FRAGS	H?O CONTENT	D	W
YOLO	0-20	D	2.5 Y	6	3	loam	37.5	41.9	20.6	-	0.0316	VH	SS
		M	2.5 Y	3	3								SP
	20-43	D	2.5 Y	5	3	loam	38.0	43.6	18.4	-	0.0626	EH	SS
		M	2.5 Y	3	3								SP
	43-60	D	2.5 Y	5	4	loam	41.5	44.0	14.5	-	0.0619	SH	SO
		M	2.5 Y	4	4								SP
HILLGATE	0-9	D	2.5 Y	6	4	loam	51.0	38.6	10.4	-	0.0121	MH	SS
		M	2.5 Y	4	4								MP
	9-26	D	2.5 Y	6	4	loam	50.9	36.2	12.9	-	0.0186	SH	SS
		M	10 YR	4	4								SP
	26-35	D	10 YR	5	4	sandy loam	53.5	35.5	11.0	-	0.0131	HA	VS
		M	10 YR	4	4								MP
	35-67	D	10 YR	5	4	sandy loam	52.6	34.8	12.6	-	0.0216	HA	VS
		M	10 YR	4	4								MP
CORNING	0-33	D	2.5 Y	6	4	sandy loam	64.0	23.9	12.1	50% GR	0.0116	MH	SS
		M	10 YR	4	4								SP
	33-43	D	10 YR	6	4	sandy loam	63.2	19.5	17.3	70% GR	0.029	HA	SS
		M	7.5 YR	4	6								MP
	43-57	D	7.5 YR	4	6	sandy clay loam	63.4	14.2	22.4	66% GR	0.0427	MH	SS
		M	5 YR	4	6								MP

Results: Physical Characteristics

- Color
  - Soil progressively redder with age
  - Leaching and accum. of Fe-oxides
- Clay content and distribution

Chemical Characteristics

SOIL	DEPTH (cm)	pH	OM %	CEC	Ca cmol/kg soil	Mg cmol/kg soil	Na cmol/kg soil	K cmol/kg soil	BS
YOLO	0-20	6.87	2.41	12.5	5.43	6.77	0.56	0.60	107
	20-43	7.51	0.65	12.4	4.22	6.21	0.66	0.37	92
	43-60	7.61	0.87	13.7	4.58	7.27	0.93	0.21	95
HILLGATE	0-9	8.2	1.27	6.6	17.94	0.85	0.66	0.25	298
	9-26	8.53	0.79	7.4	3.05	3.88	1.05	0.17	110
	26-35	8.42	0.26	10.7	3.47	5.37	1.54	0.18	99
	35-67	8.34	n.d.*	4.9	2.83	1.89	0.58	0.16	112
CORNING	0-33	6.15	0.96	5.9	2.30	2.23	0.64	0.15	90
	33-43	6.27	n.d.*	8.3	2.68	3.45	0.63	0.15	83
	43-57	6.66	n.d.*	5.0	4.12	1.16	0.91	0.18	128

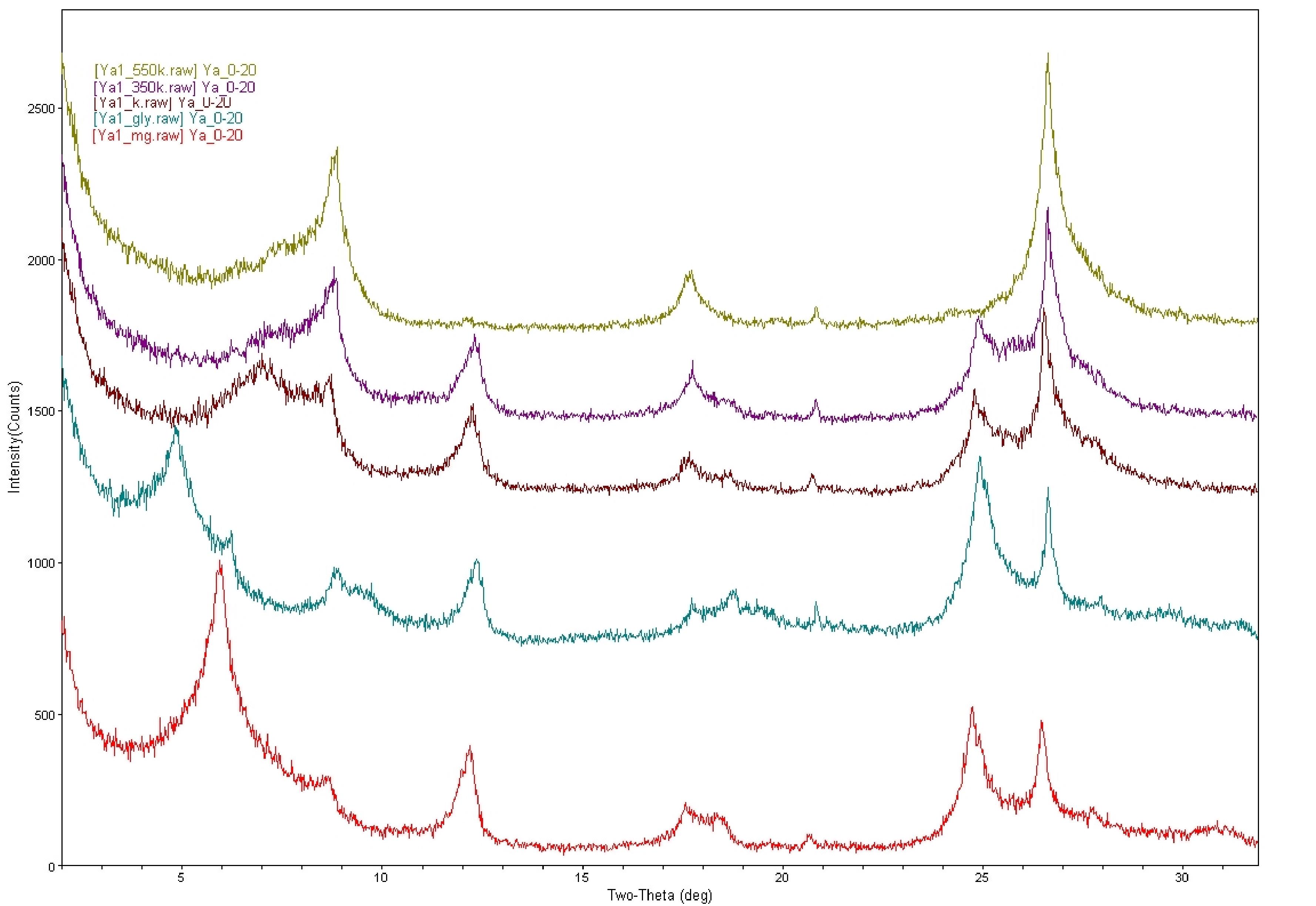
*n.d. = none detected

Results: Chemical Characteristics

- pH
  - Ca^{2+} limitation in Hillgate soil
  - Soils in range to dissociate P from constituents → more readily available
  - Higher clay content could help hold nutrients in rooting zone
  - Little OM to contribute to release of N & S
    - OM distribution relative to pH

Results: Chemical Characteristics

- CEC
  - Low OM contribution
  - Decrease in nutrient abundance with age
    - Mineral desilication



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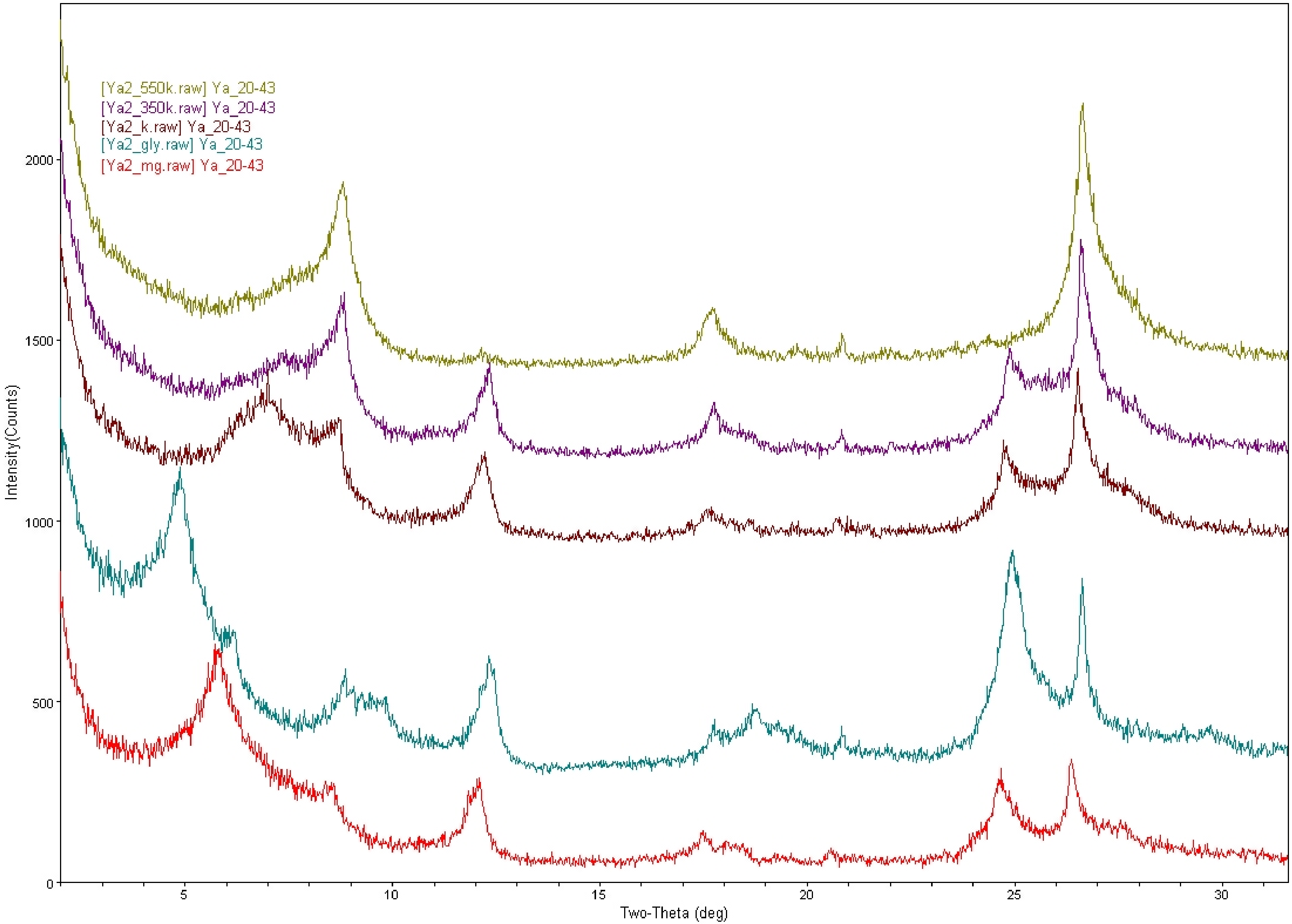

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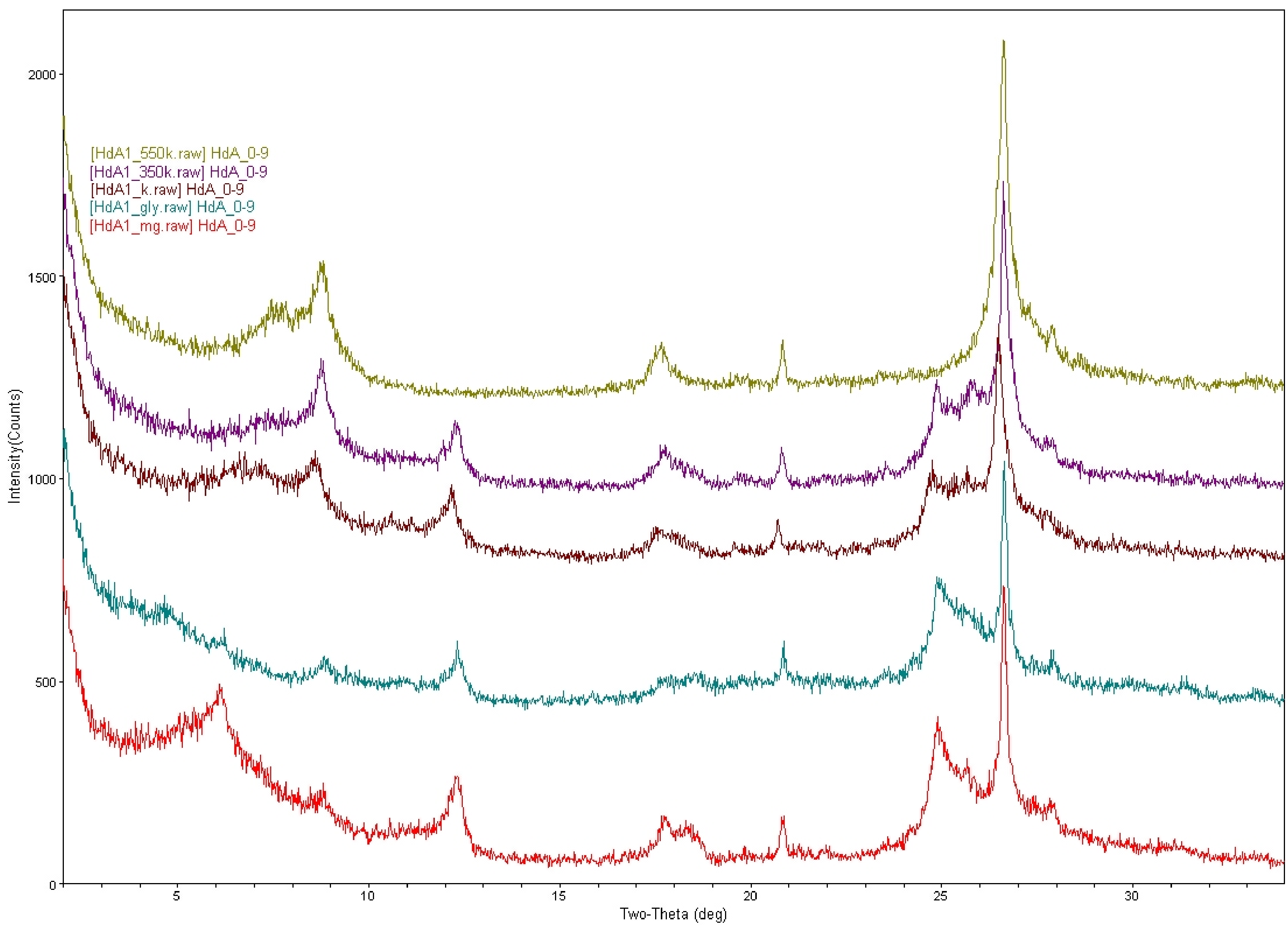

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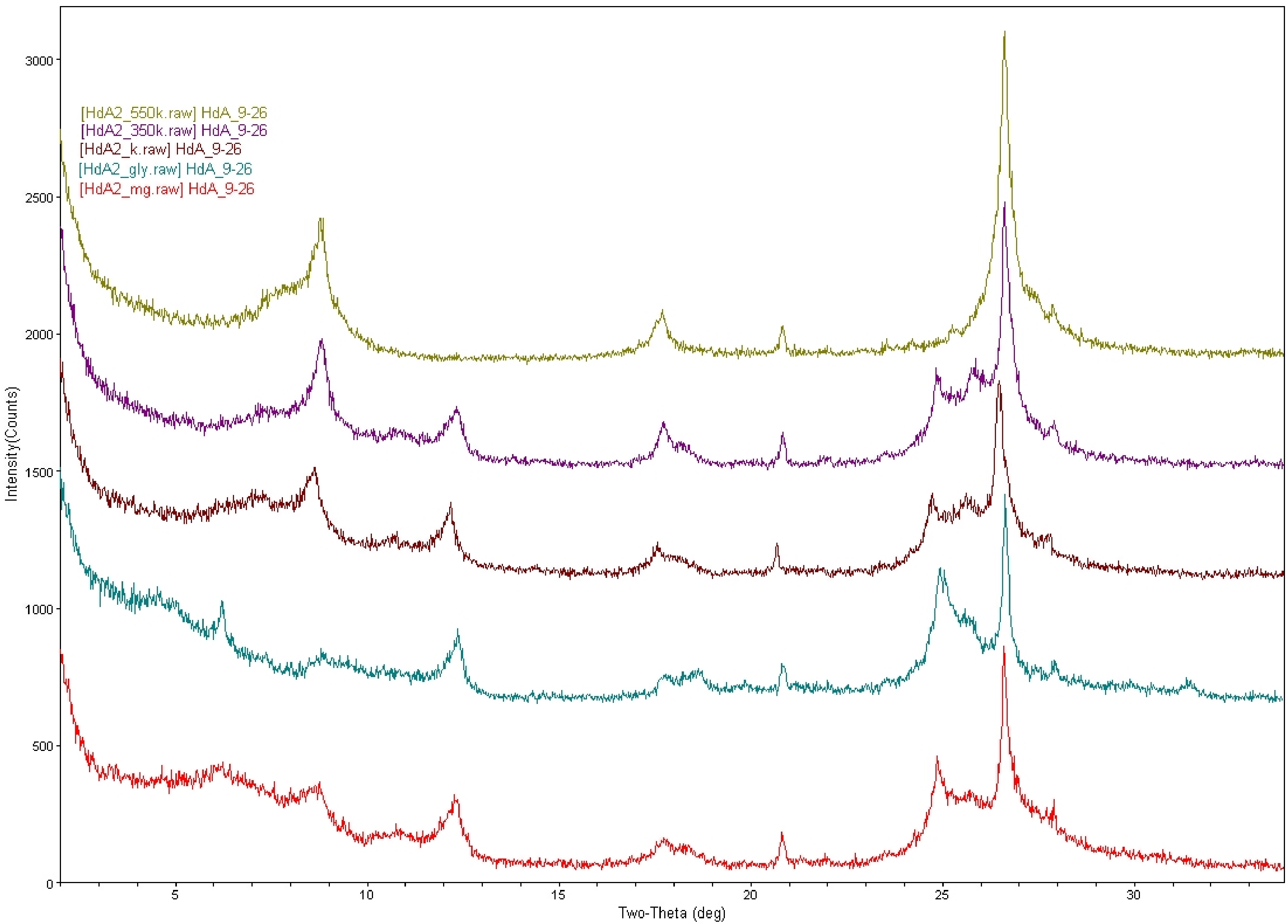

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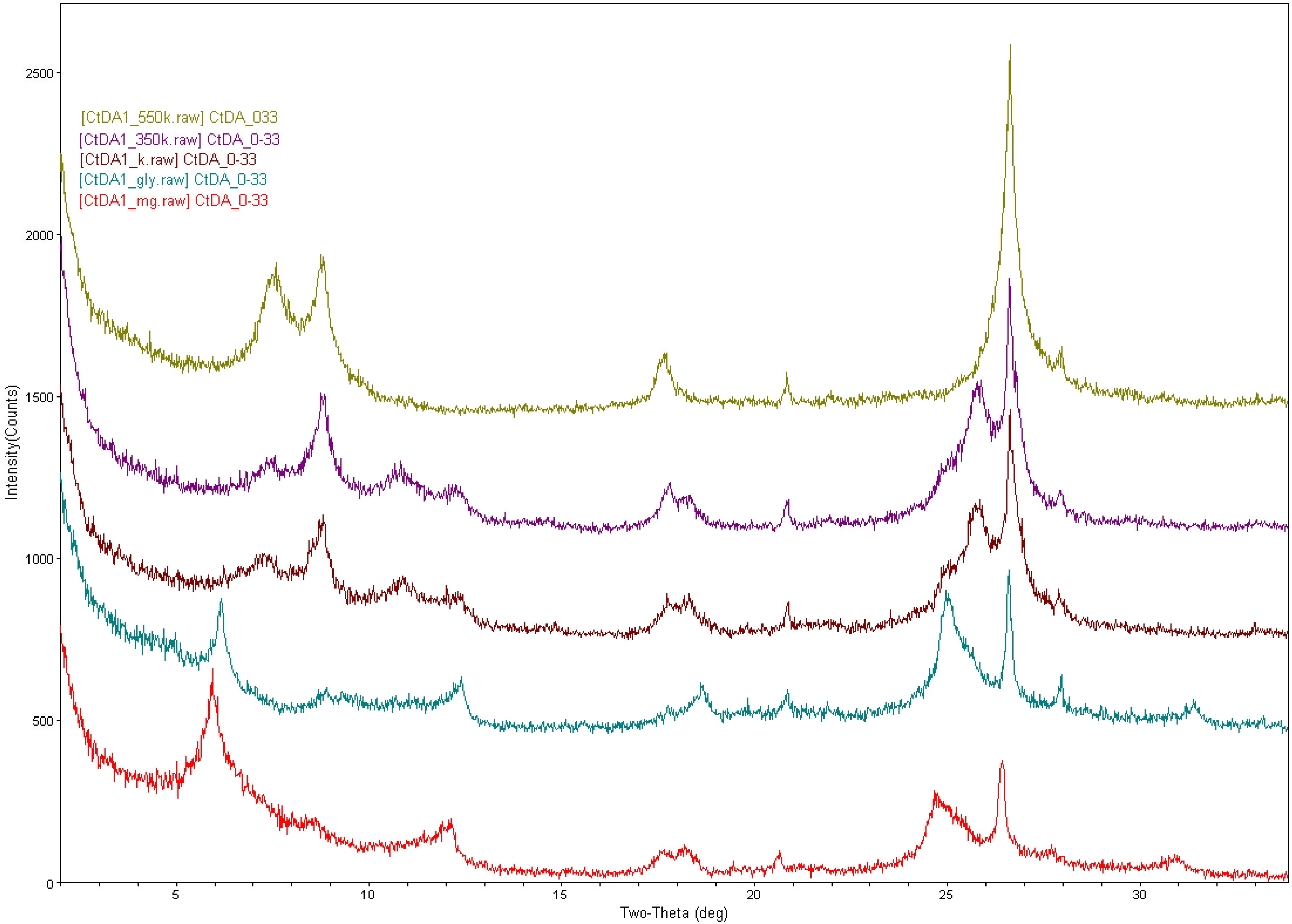

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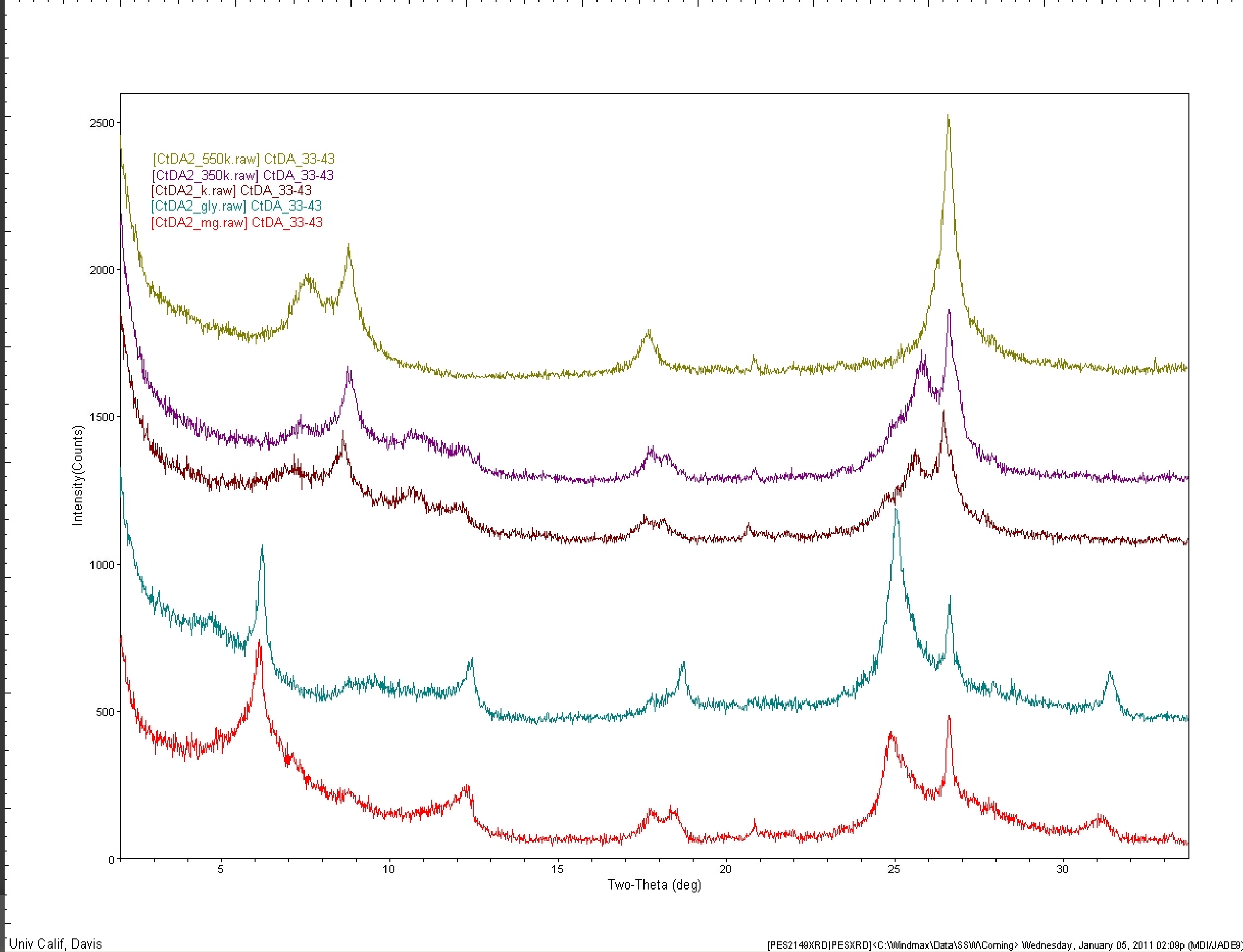
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Intensity(Counts)
2500
2000
1500
1000
500
0
5
10
15
20
25
30
Two-Theta (deg)
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[PES2149XRD|PESXRD]<C:\Windmax\Data\SSW\Corning> Wednesday, January 05, 2011 02:09p (MDI/JADE9)

Results: Minerology

- Yolo
  - Smectite
  - Vermiculite
  - Kaolinite
  - Quartz
  - Mica
- Hillgate
  - Same as Yolo
  - Feldspar
  - Weakening of Smectite collapse
- Corning
  - Similar to previous
  - Weakening of Smcetite collapse
  - Mica absent

Conclusion

- Smectite collapse
  - Water disassociates from hydrated Al causing Al-polymerization
    - Polymers deposited between interlayers → HIMs → superlattice effect
    - HIMs replace smectite crystllinity
- Hydroxy interlayering
  - Decrease BS
  - Increase acidity (as in Corning)
  - Interlayer pockets trap K & cause selectivity in the exchange complx

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