GEORGIA INSTITUTE OF TECHNOLOGY — OFFICE OF CONTRACT ADMINISTRATION

PROJECT ADMINISTRATION DATA SHEET

[X] ORIGINAL [ ] REVISION NO. ______

Project No. G-35-682 (R6205-0A0) GTRC/~~GIT~~ DATE 9 /15 / 86

Project Director: Ed Patterson School/~~Lab~~ Geo Sci

Sponsor: USDA, Forest Service-Pacific Northwest Research Station

Type Agreement: Cooperative Research Agreement No. PNW86-524

Award Period: From 8/13/86 To ~~8/1/87~~ 12/1/89 (Performance) 8/1/87 (Reports)

Sponsor Amount:

	This Change	Total to Date
Estimated:	$ 10,000	$ 10,000
Funded:	$ 10,000	$ 10,000

Cost Sharing Amount: $ 2,072 Cost Sharing No: G-35-373 (F6205-0A0)

Title: Light Absorption Properties of Particles in Smoke From Burning of Forest Fuels

ADMINISTRATIVE DATA

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Defense Priority Rating: N/A

Military Security Classification: N/A
(or) Company/Industrial Proprietary: N/A

RESTRICTIONS

See Attached N/A Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval – Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with none proposed or anticipated.

COMMENTS:

SEP 1986 RECEIVED SUPPORT SERVICE OCA

COPIES TO: SPONSOR'S I. D. NO. 02.109.[illegible]

Project Director	Procurement/GTRI Supply Services	GTRC
Research Administrative Network	~~Research Security Services~~	Library
Research Property Management	Reports Coordinator (OCA)	Project File
Accounting	Research Communications (2)	Other A. Jones

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

NOTICE OF PROJECT CLOSEOUT

Closeout Notice Date 03/12/91

:oject No. G-35-682 Center No. R6205-0A0

:oject Director PATTERSON E M School/Lab E & A SCI

›onsor US DEPT OF AGRICULTURE/FOREST SERVICE

›ntract/Grant No. PNN86-524 Contract Entity GTRC

:ime Contract No.

:tle LIGHT ABSORPTION PROPERTIES OF SMOKE PARTICLES

:fective Completion Date 891201 (Performance) 891201 (Reports)

.oseout Actions Required:	Y/N	Date Submitted
Final Invoice or Copy of Final Invoice	Y	
Final Report of Inventions and/or Subcontracts	Y	
Government Property Inventory & Related Certificate	N	
Classified Material Certificate	N	
Release and Assignment	N	
Other	N	

CommentsINVOICE VIA SF 270.

ıbproject Under Main Project No.

ıntinues Project No.

.stribution Required:

Project Director	Y
Administrative Network Representative	Y
GTRI Accounting/Grants and Contracts	Y
Procurement/Supply Services	Y
Research Property Managment	Y
Research Security Services	N
Reports Coordinator (OCA)	Y
GTRC	Y
Project File	Y
Other	N
	N

'TE: Final Patent Questionnaire sent to PDPI.

Light Absorption Properties of Particles in Smoke from Burning of Forest Fuels

Quarterly Progress Report

Covering the Period

13 August, 1986 to 31 December, 1986

for

Cooperative Agreement Number PNW 86-524

Submitted by

Edward M. Patterson
School of Geophysical Sciences
Georgia Institute of Technology
Atlanta Georgia 30332

Submitted to

United States Department of Agriculture / Forest Service
Forestry Sciences Laboratory
4043 Roosevelt Way, NE
Seattle, WA 98105

During this time period, plans for the experimental procedures were developed, and work was begun on the optical absorption analysis of the filter samples from the 1986 burns.

Measurements and analysis were done for the three Lodi Canyon burns. The goal of these measurements was the determination of B_a, the specific absorption, which is a measure of the effectiveness of a given smoke in producing optical absorption.

These results are shown on the following pages of this report. The Tables describing the results include information on the particular fire and fire phase in which the sample was collected, a Filter ID which identifies the particular sample, the sampling package in which the filter sample was collected, τ_a, the absorption optical depth, the mass loading on the filter, and B_a, the specific absorption coefficient. τ_a has been adjusted to account for filter effects as described in earlier reports.

LODI I

ID	Phase	Pkg	τ_a	Mass(mg)	B_a
601	F	1	1.67	6.22	.322
602	F	3	1.21	2.33	.623
603	F	5	0.88	1.34	.788

LODI 2

ID	Phase	Pkg	τ_a	Mass(mg)	B_a
692	F	3	.48	1.32	.433
693	F	1	2.02	8.93	.271
694	F	4	.152	.30	.608
685	S1	5	.098	0.20	.588

LODI 3

ID	Phase	Pkg	τ_a	Mass(mg)	B_a
581	F	1	1.31	1.73	.909
583	F	3	.87	1.72	.609
584	F	5	1.91	.278	.824
591	S1	1	1.16	4.64	.300
593	S1	3	.497	1.30	.458
594	S1	5	.045	0.23	.234

Light Absorption Properties of Particles in Smoke from Burning of Forest Fuels

Progress Report Number 2

Covering the Period

1 January, 1987 to 31 March, 1987

for

Cooperative Agreement Number PNW 86-524

Submitted by

Edward M. Patterson
School of Geophysical Sciences
Georgia Institute of Technology
Atlanta Georgia 30332

Submitted to

United States Department of Agriculture / Forest Service
Forestry Sciences Laboratory
4043 Roosevelt Way, NE
Seattle, WA 98105

During this time period, work continued on the optical absorption analysis of the filter samples from the 1986 burns.

Measurements and analysis were done for the four Pile burns. As in the previous measurements, the goal of these measurements was the determination of B_a, the specific absorption, which is a measure of the effectiveness of a given smoke in producing optical absorption.

These results are shown on the following pages of this report. The Tables describing the results include information on the particular fire and fire phase in which the sample was collected, a Filter ID which identifies the particular sample, the sampling package in which the filter sample was collected, τ_a, the absorption optical depth, the mass loading on the filter, and B_a, the specific absorption coefficient. τ_a has been adjusted to account for filter effects as described in earlier reports.

PILE 1

ID	Phase	Pkg	τ_a	Mass(mg)	B_a
591	F	1	1.04	1.58	.790
531	S1	1	.324	.89	.437
532	S1	2	.585	2.06	.341
534	S1	4	.345	1.07	.387
535	S1	5	.106	.191	.666

PILE 2

ID	Phase	Pkg	τ_a	Mass(mg)	B_a
541	F	1	.27	.35	.926
543	F	3	.145	.176	.989
642	S1	1	.48	1.57	.367
643	S1	3	.62	2.49	.299

PILE 3

ID	Phase	Pkg	τ_a	Mass(mg)	B_a
621	F	1	.348	.64	.653
622	F	3	.872	1.60	.654
623	F	5	.361	.48	.903
671	S1	1	.87	4.00	.261
672	S1	3	1.92	18.73	.123
673	S1	5	.545	1.92	.341

PILE 4

ID	Phase	Pkg	τ_a	Mass(mg)	B_a
561	F	1	.394	.848	.558
562	F	3	1.45	4.37	.398
563	F	5	.61	.84	.869
591	S2	1	.72	3.18	.272
593	S2	3	.93	1.80	.620
594	S2	4	.079	.26	.365
531	S3	1	.406	1.40	.348
532	S3	2	.61	2.50	.293
533	S3	3	.89	4.93	.217
534	S3	4	.56	2.25	.299

Light Absorption Properties of Particles in Smoke from Burning of Forest Fuels

Progress Report Number 3

Covering the Period

1 April, 1987 to 30 June, 1987

for

Cooperative Agreement Number PNW 86-524

Submitted by

Edward M. Patterson
School of Geophysical Sciences
Georgia Institute of Technology
Atlanta Georgia 30332

Submitted to

United States Department of Agriculture / Forest Service
Forestry Sciences Laboratory
4043 Roosevelt Way, NE
Seattle, WA 98105

During this time period, work continued on the optical absorption analysis of the filter samples from the 1986 burns.

Measurements and analysis were done for the LB series of burns. As in the previous measurements, the goal of these measurements was the determination of B_a, the specific absorption, which is a measure of the effectiveness of a given smoke in producing optical absorption.

These results are shown on the following pages of this report. The Tables describing the results include information on the particular fire and fire phase in which the sample was collected, a Filter ID which identifies the particular sample, the sampling package in which the filter sample was collected, τ_a, the absorption optical depth, the mass loading on the filter, and B_a, the specific absorption coefficient. τ_a has been adjusted to account for filter effects as described in earlier reports.

LB1

ID	Phase	Pkg	τ_a	Mass(mg)	B_a
502	F	2	1.22	1.94	.755
503	F	3	1.26	2.03	.745
504	F	4	.90	1.27	.851
505	F	5	.82	1.40	.703
522	S1	2	1.98	21.24	.112
523	S1	3	1.96	28.67	.082
524	S1	4	1.14	10.31	.133
525	S1	5	1.12	9.05	.149

LB 2

ID	Phase	Pkg	τ_a	Mass(mg)	B_a
571	F		.594	1.40	.509
572	F		.90	2.24	.482
573	F		.88	2.05	.515
575	F		.42	.88	.573
642	S1	2	.34	1.41	.289
643	S1	3	.56	2.41	.279
645	S1	5	.41	1.83	.269

LB 3

ID	Phase	Pkg	τ_a	Mass(mg)	B_a
601	F	1	1.50	3.06	.588
602	F	2	.70	1.04	.808
603	F	3	1.47	4.16	.424
604	F	4	1.48	8.35	.213
605	F	5	1.94	14.17	.164
613	S1	3	1.06	6.00	.212
631	S2	1	.315	2.51	.151
632	S2	2	.242	1.59	.183
633	S2	3	.391	2.68	.175
634	S2	4	.355	2.66	.160
635	S2	5	.51	3.72	.166

LB 4

ID	Phase	Pkg	τ_a	Mass(mg)	B_a
621	F	1	.91	2.50	.437
622	F	2	1.05	4.42	.285
623	F	3	1.88	10.7	.177
625	F	5	1.55	11.8	.158
674			1.34	8.53	.189
571	S2	1	.55	3.61	.183
572	S2	2	.248	.48	.62
573	S2	3	.445	4.77	.112
574	S2	4	.345	5.10	.081
575	S2	5	.50	2.62	.229

Light Absorption Properties of Particles in Smoke from Burning of Forest Fuels

Progress Report Number 4

Covering the Period

1 July, 1987 to 31 December, 1987

for

Cooperative Agreement Number PNW 86-524

Submitted by

Edward M. Patterson
School of Geophysical Sciences
Georgia Institute of Technology
Atlanta Georgia 30332

Submitted to

United States Department of Agriculture / Forest Service
Forestry Sciences Laboratory
4043 Roosevelt Way, NE
Seattle, WA 98105

During this time period, work continued on the optical absorption analysis of the filter samples from the 1986 burns.

Measurements and analysis were done for three sets of burn data: Coles, LL, and Cedar Pollard. As in the previous measurements, the goal of these measurements was the determination of B_a, the specific absorption, which is a measure of the effectiveness of a given smoke in producing optical absorption.

These results are shown on the following pages of this report. The Tables describing the results include information on the particular fire and fire phase in which the sample was collected, a Filter ID which identifies the particular sample, the sampling package in which the filter sample was collected, τ_a, the absorption optical depth, the mass loading on the filter, and B_a, the specific absorption coefficient. τ_a has been adjusted to account for filter effects as described in earlier reports.

COL 1

ID	Phase	Pkg	τ_a	Mass(mg)	B_a
661	F	5	1.26	3.08	.491
662	F	4	.80	.95	1.01
663	F	3	.86	1.20	.86
551	S1		1.28	5.97	.257
552	S1		.99	3.76	.316
553	S1		1.09	5.09	.257

COL 2

ID	Phase	Pkg	τ_a	Mass(mg)	B_a
531	F		1.01	1.37	.885
533	F		1.23	1.80	.820
535	F		1.28	1.36	1.13
561	S1		1.99	12.47	.191
563	S1		1.49	7.59	.236
565	S1		1.94	7.92	.294

LL 1

ID	Phase	Pkg	τ_a	Mass(mg)	B_a
662	FS1	1	1.84	14.13	.156
663	FS1	3	1.70	12.66	.161
664	FS1	5	.98	6.10	.193

LL 2

ID	Phase	Pkg	τ_a	Mass(mg)	B_a
632	F	1	1.36	1.78	.916
631	S1	1	1.42	11.02	.155
633	S1	5	1.26	4.68	.323
681	F	5	.93	1.33	.839
683	F	3	1.38	3.60	.460
682	S1	3	1.45	11.27	.154

CEDPOL

ID	Phase	Pkg	τ_a	Mass(mg)	B_a
581	F	1	.548	.484	1.36
582	F	3	1.39	1.99	.839
583	F	5	1.81	2.68	.810
572	F	4	1.68	6.51	.310
611	S1	1	1.15	6.45	.214
612	S1	3	1.45	8.45	.206
613	S1	5	1.60	11.09	.173
571	S1	4	.645	2.58	.300
501	S2	1	.206	1.02	.242
502	S2	2	.130	.70	.223
503	S2	3	.203	1.00	.244
504	S2	4	.161	.72	.268
505	S2	5	.203	.90	.271

6-35-682

Estimates of the Absorption Parameters for the Smoke Emissions from Prescribed Burns

Edward M. Patterson
Georgia Institute of Technology
Atlanta, Georgia 30332

Final Report

for

Cooperative Agreement PNW-86-524

March 1, 1991

INTRODUCTION

Prescribed burning is an important tool for the management of vegetation; the smoke emissions from this prescribed burning are a concern, however, because of air quality considerations. Little data has been available on the optical effects of the smoke emission from prescribed burning of vegetative fuels. In this report we present data on the absorption properties of smoke emissions from a number of burns, estimate the importance ofthe absorption in determining attenuation, and prescribe a methodology for determining the visibility reducing effects of these fuels. These measurements were made for fires conducted in the Pacific Northwest as well as in southern California (Lodi 1, Lodi 2, and Lodi 3).

OPTICAL FORMALISM

The optical effects of a smoke aerosol will be determined by the optical properties of the aerosol and by the amount of the smoke produced by a given amount of fuel, the emission factor for the fuel. Aerosol optical properties can be described by several quantities. The optical depth δ as a function of wavelength is a measure of the total optical effect of the aerosol layer. The optical depth of an atmospheric aerosol layer is defined by the equation

$$\delta = -\ln (I/I_o) \qquad (1)$$

in which I is the intensity of a direct beam of light after passing vertically through the layer and I_o is the initial intensity. The extinction coefficient, σ_e, is a measure of the amount of light removed from a beam of light per unit length. For a given path, δ and σ_e are related by the equation

$$\delta = \int \sigma_e(x)dx \qquad (2)$$

The extinction of light is due to both scattering, in which the light is removed from the incident beam and redirected, and absorption, in which there is ne reradiation of light by the particles. The coefficients are related by the equation

$$\sigma_e = \sigma_s + \sigma_a \qquad (3)$$

The visual range is a measure of the visibility that is defined in terms of contrast ratios. The extinction σ_e at mid visible wavelengths is also related to the visual range V by the Koschmeider relation

$$V = 3.9/\sigma_e \tag{4}$$

for a uniform haze.

To relate these quantities to the microphysical properties of the aerosol, we can define specific attenuation, scattering and absorption coefficients by calculating the ratio of the optical quantity (σ_e, σ_s, or σ_a) to the mass concentration of the aerosol. These specific extinction or absorption coefficients are measures of the effectivness of a given amount of aerosol material in producing an optical effect. These specific coefficients are defined according to the equations

$$B_e = \sigma_e/M_c, \tag{5}$$

$$B_s = \sigma_s/M_c, \tag{6}$$

and

$$B_a = \sigma_a/M_c \tag{7}$$

with B_e the specific extinction, B_s the specific scattering, B_a the specific absorption, and M_c the mass concentration of the aerosol. The measurements reported here are B_a measurements; as before, B_e is the sum of B_s and B_a.

Particulate emission factors can be combined with the specific attenuation and related coefficients to define new quantities B_e', B_s', and B_a', which we term the fuel specific attenuation, scattering, and absorption coefficients. These quantities are defined by the equations

$$B_e' = B_e \times EF \tag{8}$$

$$B_s' = B_s \times EF \tag{9}$$

$$B_a' = B_a \times EF \tag{10}$$

The fuel specific quantities are of interest because they are a direct measure of the optical effects of the smoke emissions from the burning of a given amount of fuel. Given a mass of fuel burned and an area covered by the smoke, the average optical depth due to the smoke may be determined using the equation

$$\delta = \frac{B_e' \ M_f}{A} \qquad (11)$$

with M_f the mass of fuel murned and A the Area covered by the smoke. If a given smoke thickness h is assumed, then σ_e is given by

$$\sigma_e = \frac{B_e' \ M_f}{A \ h} . \qquad (12)$$

Equations 4 and 11 may be combined to relate the visual range reduction to the mass of fuel burned

$$V = \frac{3.9 \ A \ h}{B_e' \ M_f} . \qquad (13)$$

For a given mass of fuel burned and a given volume occupied by the smoke, the larger B_e values will be associated with lower visibilities.

OPTICAL MEASUREMENTS

In this experimental program, the filter samples were analyzed at the Georgia Institute of Technology to determine the specific absorption at 633 nm for the smoke from each burn using the techniques described by Patterson and McMahon (1984). This is the basic data reported here. For further analysis, this absorption data could be converted to absorption data at 550 nm using wavelength dependencies measured by Patterson and McMahon. These 550 nm absorption values could then be combined with scattering values inferred from earlier work (Patterson and McMahon, 1984 and Tangren, 19xx) to estimate the specific extinction of the smoke at 550 nm. If the extinction estimates and particulate emission factors are then used to calculate fuel specific extinction coefficients using Eq. 8, a nominal visibility reduction could be calculated using Eq. 13, assuming a volume occupied by the smoke plume and the mass of fuel consumed.

DATA ON SMOKE OPTICAL CHARACTERISTICS

OPTICAL CALCULATIONS OF VISIBILITY IMPACT

The data considered for this report exhibit measured 633 nm B_a values that range between 0.08 and 1.0 m^2/g. 1.0 appears to be representative of the flaming combustion for the Lodi fires and other fires; The lower values represent smoldering or a combination of smoldering and flaming combustion. 0.2 is a reasonable estimate of the B_a values for the smoldering combustion. If these are converted to mid-visible 550 nm values using the wavelength dependence of Patterson and McMahon, the B_a numbers become 1.1 and 0.3 M^2/g respectively. The mid-visible specific scattering values are estimated from the data in Patterson and McMahon to be 3.2 m^2/g for smoldering and 2.9 m^2/g for flaming combustion.

Combining these values for scattering and absorption into specific attenuation values, we see that the specific attenuation values are 3.5 m^2/g for smoldering and 4.2 m^2/g for flaming combustion. The contribution of absorption to sthe total attenuation is less than 30 %. The differences between flaming and smoldering combustion are rather small; and so, for considerations of the potential for visibility reduction, these fuels should be burned in a manner that will reduce the emission factors, consistant with fire safety.

REFERENCES

Patterson, E. M. and B. T. Marshall. 1982 Diffuse reflectance and diffuse transmittance measurements of aerosol absorption at the First International Workshop on Light Absorption by Aerosols. Appl. Optics, 21, 387-393.

Patterson, E. M. and C. K. McMahon. 1984 Absorption characteristics of forest fire particulate matter. Atm. Environ., 18, 2541-2551.

Patterson, E. M., McMahon, C. K., and D. E. Ward. 1986 Absorption properties and graphitic carbon emission factors of forest fire aerosols. Geophys. Res. letters., 13, 129-132.

LODI 1

ID	Phase	Pkg.	δ_a	Mass(mg)	B_a
601	F	1	1.67	6.22	.32
602	F	3	1.21	2.33	.62
603	F	5	.88	1.34	.79

LODI 2

ID	Phase	Pkg.	δ_a	Mass(mg)	B_a
692	F	3	.48	1.32	.43
693	F	1	2.02	8.93	.27
694	F	4	.15	.30	.61
685	S1	5	.098	.20	.59

LODI 3

ID	Phase	Pkg.	δ_a	Mass(mg)	B_a
581	F	1	1.31	1.73	.91
583	F	3	.87	1.72	.61
584	F	5	1.91	.28	.82
591	S1	1	1.16	4.64	.30
593	S1	3	.50	1.30	.46
594	S1	5	.05	.23	.23

PILE 1

ID	Phase	Pkg	δ_a	Mass(mg)	B_a
591	F	1	1.04	1.58	.79
531	S1	1	.324	.89	.44
532	S1	2	.585	2.06	.34
534	S1	4	.345	1.07	.39
535	S1	5	.106	.191	.67

PILE 2

ID	Phase	Pkg	τ_a	Mass(mg)	B_a
541	F	1	.27	.35	.93
543	F	3	.145	.176	.99
642	S1	1	.48	1.57	.37
643	S1	3	.62	2.49	.30

PILE 3

ID	Phase	Pkg	τ_a	Mass(mg)	B_a
621	F	1	.348	.64	.65
622	F	3	.872	1.60	.65
623	F	5	.361	.48	.90
671	S1	1	.87	4.00	.26
672	S1	3	1.92	18.73	.12
673	S1	5	.545	1.92	.34

PILE 4

ID	Phase	Pkg	τ_a	Mass(mg)	B_a
561	F	1	.394	.848	.56
562	F	3	1.45	4.37	.40
563	F	5	.61	.84	.87
591	S2	1	.72	3.18	.27
593	S2	3	.93	1.80	.62
594	S2	4	.079	.26	.37
531	S3	1	.406	1.40	.35
532	S3	2	.61	2.50	.29
533	S3	3	.89	4.93	.22
534	S3	4	.56	2.25	.30

LB1

ID	Phase	Pkg	τ_a	Mass(mg)	B_a
502	F	2	1.22	1.94	.76
503	F	3	1.26	2.03	.75
504	F	4	.90	1.27	.85
505	F	5	.82	1.40	.70
522	S1	2	1.98	21.24	.11
523	S1	3	1.96	28.67	.082
524	S1	4	1.14	10.31	.13
525	S1	5	1.12	9.05	.15

LB 2

ID	Phase	Pkg	τ_a	Mass(mg)	B_a
571	F		.594	1.40	.51
572	F		.90	2.24	.48
573	F		.88	2.05	.52
575	F		.42	.88	.57
642	S1	2	.34	1.41	.29
643	S1	3	.56	2.41	.28
645	S1	5	.41	1.83	.27

LB 3

ID	Phase	Pkg	τ_a	Mass(mg)	B_a
601	F	1	1.50	3.06	.59
602	F	2	.70	1.04	.81
603	F	3	1.47	4.16	.42
604	F	4	1.48	8.35	.21
605	F	5	1.94	14.17	.16
613	S1	3	1.06	6.00	.21
631	S2	1	.315	2.51	.15
632	S2	2	.242	1.59	.18
633	S2	3	.391	2.68	.18
634	S2	4	.355	2.66	.16
635	S2	5	.51	3.72	.17

LB 4

ID	Phase	Pkg	τ_a	Mass(mg)	B_a
621	F	1	.91	2.50	.44
622	F	2	1.05	4.42	.29
623	F	3	1.88	10.7	.18
625	F	5	1.55	11.8	.16
674			1.34	8.53	.19
571	S2	1	.55	3.61	.18
572	S2	2	.248	.48	.62
573	S2	3	.445	4.77	.11
574	S2	4	.345	5.10	.081
575	S2	5	.50	2.62	.23

COL 1

ID	Phase	Pkg	τ_a	Mass(mg)	B_a
661	F	5	1.26	3.08	.49
662	F	4	.80	.95	1.01
663	F	3	.86	1.20	.86
551	S1		1.28	5.97	.26
552	S1		.99	3.76	.32
553	S1		1.09	5.09	.26

COL 2

ID	Phase	Pkg	τ_a	Mass(mg)	B_a
531	F		1.01	1.37	.89
533	F		1.23	1.80	.82
535	F		1.28	1.36	1.13
561	S1		1.99	12.47	.19
563	S1		1.49	7.59	.24
565	S1		1.94	7.92	.29

LL 1

ID	Phase	Pkg	τ_a	Mass(mg)	B_a
662	FS1	1	1.84	14.13	.16
663	FS1	3	1.70	12.66	.16
664	FS1	5	.98	6.10	.19

LL 2

ID	Phase	Pkg	τ_a	Mass(mg)	B_a
632	F	1	1.36	1.78	.92
631	S1	1	1.42	11.02	.16
633	S1	5	1.26	4.68	.32
681	F	5	.93	1.33	.84
683	F	3	1.38	3.60	.46
682	S1	3	1.45	11.27	.15

CEDPOL

ID	Phase	Pkg	τ_a	Mass(mg)	B_a
581	F	1	.548	.484	1.36
582	F	3	1.39	1.99	.84
583	F	5	1.81	2.68	.81
572	F	4	1.68	6.51	.31
611	S1	1	1.15	6.45	.21
612	S1	3	1.45	8.45	.21
613	S1	5	1.60	11.09	.17
571	S1	4	.645	2.58	.30
501	S2	1	.206	1.02	.24
502	S2	2	.130	.70	.22
503	S2	3	.203	1.00	.24
504	S2	4	.161	.72	.27
505	S2	5	.203	.90	.27