## CONTENTS

## ENVIRONMENTAL HEALTH CRITERIA FOR BENTONITE, KAOLIN, AND SELECTED CLAY MINERALS

PREAMBLE						
AC	RON	YMS A	AND ABBREVIATIONS	xvi		
1.	SUN	MMAR	Y	1		
	1.1	Identit	y, physical and chemical properties, and			
		analyti	ical methods	1		
	1.2	Source	es of human and environmental exposure	2		
	1.3	Enviro	onmental levels and human exposure	2		
	1.4 Kinetics and metabolism in laboratory animals					
	and humans					
	1.5	Effects	s on laboratory mammals and in vitro test			
	systems					
	1.6	Effects	s on humans	5		
	1.7	Effects	s on other organisms in the laboratory and field	6		
	1.8	Evalua	ation of human health risks and effects on the			
		enviro	nment	6		
2.	IDENTITY, PHYSICAL AND CHEMICAL					
	PRO	OPERT	IES, AND ANALYTICAL METHODS	8		
				0		
	2.1	Introduction				
	2.2	Identit	y .	9		
		2.2.1	Bentonite	9		
		2.2.2	Kaolin	11		
		2.2.3	Other clays	12		
	2.3	Physic	cal and chemical properties	14		
		2.3.1	Bentonite	14		
		2.3.2	Kaolin	15		
		2.3.3	Other clays	15		
		2.3.4	Surface chemistry	1/		
		2.3.5	I race elements in clays	10		
	2.4 Analytical methods					
		2.4.1	Quantitative measurement of dust	19		
		2.4.2	Identification of phyllosilicates	20		

iii

3.	. SOURCES OF HUMAN AND ENVIRONMENTAL					
	EXPOSURE	23				
	3.1 Natural occurrence	23				
	3.1.1 Bentonite	23				
	3.1.2 Kaolin	23				
	3.1.3 Other clays					
	3.2 Anthropogenic sources					
	3.2.1 Production levels and sources	25				
	3.2.1.1 Bentonite	25				
	3.2.1.2 Kaolin	27				
	3.2.1.3 Other clays	30				
	3.2.2 Uses	31				
	3.2.2.1 Bentonite	31				
	3.2.2.2 Kaolin	34				
	3.2.2.3 Other clays	37				
4.	ENVIRONMENTAL LEVELS AND HUMAN					
	EXPOSURE	40				
	4.1 General population exposure	40				
	4.1.1 Bentonite	40				
	4.1.2 Kaolin and other clays	40				
	4.2 Occupational exposure	42				
	4.2.1 Bentonite	42				
	4.2.2 Kaolin	45				
	4.2.3 Other clays	54				
5.	KINETICS AND METABOLISM IN LABORATORY					
	ANIMALS AND HUMANS	56				
6	FEFECTS ON LABORATORY MAMMALS AND					
0.	IN VITRO TEST SYSTEMS	50				
	IN VIIKO IESI SISIEMS	39				
	6.1 Single exposure	59				
	6.1.1 Bentonite	59				
	6.1.2 Kaolin	70				
	6.1.2.1 Intratracheal administration	70				
	6.1.2.2 Parenteral administration	77				
	6.1.3 Other clays	77				
	6.2 Repeated exposure	78				

		6.2.1	Bentonit	te	78		
		6.2.2	Kaolin		82		
	6.3	Genotoxicity					
	6.4	Reproductive effects					
	6.5	Admi	nistration	with other agents	84		
		6.5.1	Kaolin a	nd microbes and microbe-derived			
			factors		84		
		6.5.2	Kaolin a	nd quartz	85		
	6.6	In vitro test systems			85		
		6.6.1 Bentonite					
		6.6.2	Kaolin		97		
			6.6.2.1	Haemolysis	97		
			6.6.2.2	Macrophage studies	108		
			6.6.2.3	Other tissue cultures and in vitro			
				systems	109		
		6.6.3	Other cla	ays	110		
		6.6.4	Relation	ships between in vivo and in vitro			
			studies		110		
	6.7	Sumn	hary of the	e effects of quartz	110		
7	EEI		ONTRO		112		
1.	EFFECTS ON HUMANS						
	7.1	Gener	al popula	tion	112		
	7.2	Occup	pational e	xposure	112		
		7.2.1	Bentonit	te	112		
		7.2.2	Kaolin		118		
			7.2.2.1	Kaolin workers, United Kingdom	119		
			7.2.2.2	Kaolin workers, USA	128		
			7.2.2.3	Kaolin workers, other countries	130		
			7.2.2.4	Brick and tile workers and others	130		
	7.3	Sumn	hary of th	e effects of quartz	131		
0	DEI	TECTO	ONOTI	IED OD CANIENCE IN THE			
δ.	EFI	EFFEUIS UN UTHER URGANISMS IN THE					
	LA	BORA	IORYA	ND FIELD	155		
9.	EV	ALUA	TION OF	F HUMAN HEALTH RISKS AND			
	EFFECTS ON THE ENVIRONMENT						
	9.1	Evalu	ation of h	numan health risks	135		
	9.2	Evalu	ation of e	effects on the environment	137		

V

10. CONCLUSIONS AND RECOMMENDATIONS FOR PROTECTION OF HUMAN HEALTH AND THE		
ENVIRONMENT	138	
11. FURTHER RESEARCH	139	
12. PREVIOUS EVALUATIONS BY INTERNATIONAL		
BODIES	140	
REFERENCES		
RESUME	160	
RESUMEN	168	

,