

Chemical analysis of organic molecules in

for citation and similar papers at core.ac.uk

brought

provided by Leiden University

Proefschrift

ter verkrijging van
de graad van Doctor aan de Universiteit Leiden,
op gezag van de Rector Magnificus Dr. D. D. Breimer,
hoogleraar in de faculteit der Wiskunde en
Natuurwetenschappen en die der Geneeskunde,
volgens besluit van het College voor Promoties
te verdedigen op woensdag 24 Januari 2007
klokke 16.15 uur

door

Zita Carla Torrão Pinto Martins
geboren te Lisboa, Portugal, in 1979

Promotiecommissie

Promotor: Prof. Dr. P. Ehrenfreund

Referent: Dr. G. Cody (Carnegie Institution of Washington, USA)

Overige leden: Dr. O. Botta (International Space Science Institute, Switzerland)
Prof. Dr. G. Davies (Vrije Universiteit Amsterdam)
Prof. Dr. J. Fraaije
Prof. Dr. J. Lugtenburg
Prof. Dr. A. Schwartz (Radboud University Nijmegen)
Dr. M. Sephton (Imperial College London, UK)

To my family: Mum, Dad, Paulo, Tuxa e Pedro

Cover: Painting by Russian artist P. I. Medvedev showing the Sikhote-Alin iron meteorite fall on the 12th February 1947 in Eastern Siberia, Russia.



CONTENTS

Chapter 1 Introduction	1
1.1 Heavenly stones-from myth to science.....	1
1.2 Meteorite classification.....	5
1.2.1 Iron meteorites.....	5
1.2.2 Stony-iron meteorites.....	6
1.2.3 Stony meteorites.....	6
1.2.3.1 Achondrites.....	6
1.2.3.2 Chondrites.....	8
1.3 Primitive organic matter kits.....	11
1.4 Thesis outline.....	14
Chapter 2 Free dicarboxylic and aromatic acids in the carbonaceous chondrites Murchison and Orgueil	21
2.1 Introduction.....	22
2.2 Materials and Methods.....	24
2.2.1 Extraction procedure and GC-MS analysis.....	24
2.3 Results and Discussion	25
2.3.1 Carboxylic acids detected	25
2.3.2 Origin of meteoritic organic acids	29
2.4 Conclusion	30
Chapter 3 Extraterrestrial nucleobases in the Murchison meteorite	33
3.1 Introduction.....	34
3.2 Materials and Methods.....	36
3.2.1 Chemicals and reagents.....	36
3.2.2 Extraction and cleaning procedure.....	36
3.2.3 Determination of the nucleobase recoveries.....	36
3.2.4 GC-QMS analysis.....	37
3.2.5 GC-C-IRMS analysis.....	38
3.3 Results and Discussion	38
3.3.1 Carboxylic acids in the Murchison meteorite and soil samples	42
3.4 Conclusion	44
Appendix.....	45

Chapter 4 Amino acids in Antarctic CM1 meteorites and their relationship to other carbonaceous chondrites	49
4.1 Introduction.....	50
4.2 Materials and Methods.....	52
4.2.1 Chemicals and reagents.....	52
4.2.2 Meteorite sample preparation, extraction and purification.....	52
4.2.3 HPLC analysis.....	53
4.2.4 GC-MS analysis.....	53
4.3 Results and Discussion	54
4.3.1 Absolute amino acid concentrations.....	54
4.3.2 Relative amino acid abundances.....	60
4.3.3 Implications for parent body processes.....	63
4.4 Summary and Conclusion	64
Chapter 5 Amino acid composition, petrology, geochemistry, ¹⁴C terrestrial age and oxygen isotopes of the Shisr 033 CR chondrite	69
5.1 Introduction.....	70
5.2 Materials and Methods.....	70
5.2.1 Samples and sample preparation.....	70
5.2.2 Chemicals, reagents and tools.....	72
5.2.3 Petrology and chemistry analysis.....	72
5.2.4 Amino acid extraction procedure, HPLC-FD and LC-ToF-MS analysis.....	72
5.2.5 Oxygen and carbon isotope analysis.....	73
5.2.6 Terrestrial age analysis.....	74
5.3 Results and Discussion	74
5.3.1 Petrology.....	74
5.3.2 Chemistry.....	76
5.3.3 Amino acid composition and terrestrial contamination.....	77
5.3.3.1 Shisr 033 amino acid composition and comparison to other carbonaceous chondrites.....	83
5.3.4 Oxygen and carbon isotopes.....	87
5.3.5 Terrestrial ages and their relationship to the extend of terrestrial contamination.....	91
5.4 Conclusion	92
Chapter 6 Indigenous amino acids and chiral excess present in CR primitive meteorites	97
6.1 Introduction.....	98
6.2 Materials and Methods.....	99
6.2.1 Tools and chemicals.....	99
6.2.2 Meteorite sample preparation and amino acid extraction procedure.....	99

6.2.3	HPLC-FD analysis.....	100
6.2.4	GC-MS analysis.....	100
6.2.5	GC-C-IRMS analysis.....	101
6.3	Results and Discussion	102
6.3.1	Formation of α -meteoritic amino acids.....	111
6.4	Conclusion	113
	Nederlandse samenvatting	117
	Publication list	121
	Curriculum Vitae	123
	Acknowledgements	125

