

| | Page |
|--|------|
| CONTENTS | |
| Declaration | 2 |
| Abstract | 3 |
| Dedication | 5 |
| Acknowledgements | 6 |
| List of Figures | 10 |
| List of Tables | 12 |
| Chapter One - Introduction | |
| 1.1 General Introduction..... | 13 |
| 1.1.1 Geological setting..... | 14 |
| 1.1.2 Previous research at Gladysvale Cave..... | 18 |
| 1.2 Literature Review..... | 21 |
| 1.2.1 Cave stratigraphy..... | 21 |
| 1.2.2 Cave sediments..... | 25 |
| 1.2.3 Cyclic cave sedimentation models..... | 33 |
| 1.2.4 Uranium-series dating..... | 37 |
| 1.2.5 Stable light isotopes as records of palaeoclimate..... | 40 |
| 1.2.6 Southern African records of Quaternary climate change..... | 46 |
| 1.3 Aims..... | 54 |
| Chapter Two – Methods and material | |
| 2.1 Stratigraphy and three-dimensional sedimentary architecture..... | 55 |
| 2.1.1 Mapping..... | 55 |
| 2.1.2 Sampling..... | 55 |
| 2.2 Uranium-series ICP-MS dating, including laser ablation..... | 57 |
| 2.2.1 Sampling..... | 57 |
| 2.2.2 Background U levels pre-screening..... | 59 |
| 2.2.3 Laser ablation..... | 59 |
| 2.2.4 Dating..... | 60 |
| 2.3 Stable light isotope analysis on Finnigan Mat 252 Mass Spectrometer..... | 61 |
| 2.3.1 Sampling..... | 61 |
| 2.3.2 Standards and calibration..... | 62 |
| 2.3.3 Analysis..... | 63 |
| 2.3.4 Correction of data..... | 63 |
| Chapter Three - Geomorphology, stratigraphy and sedimentology | |
| 3.1 Introduction..... | 64 |
| 3.2 Geomorphology..... | 64 |
| 3.2.1 General fan morphology..... | 64 |
| 3.2.2 Cave entrances..... | 66 |
| 3.2.3 Fan lobes..... | 66 |
| 3.2.4 Fan lobe faces..... | 67 |
| 3.2.5 Drip centres and stalagmites..... | 68 |
| 3.3 Stratigraphy and sedimentology..... | 70 |
| 3.3.1 Flowstone bounded units..... | 70 |
| 3.3.2 Thin section petrology..... | 72 |
| 3.3.3 Fossil bone and coprolites..... | 78 |
| 3.3.4 Fossil snails..... | 80 |
| 3.3.5 Cave pearls..... | 81 |

| | Page |
|--|------|
| 3.3.6 Facies descriptions..... | 82 |
| 3.3.7 Stratigraphic sections..... | 87 |
| 3.3.8 Hydrological interpretation of facies..... | 116 |
| Chapter Four – Uranium-series dating of Gladysvale flowstones | |
| 4.1 Introduction..... | 120 |
| 4.2 Background U-screening..... | 111 |
| 4.3 LA-ICP-MS..... | 121 |
| 4.3.1 U and Th concentrations in Gladysvale Flowstones..... | 124 |
| 4.3.2 Trace element distributions in Gladysvale Flowstones..... | 126 |
| 4.4 Uranium series..... | 131 |
| 4.4.1 Data..... | 131 |
| 4.4.2 $^{230}\text{Th}/^{238}\text{U}$ ages..... | 133 |
| 4.4.3 $^{230}\text{Th}/^{232}\text{Th}$ activity ratios and age correction..... | 134 |
| 4.4.4 Initial $^{234}\text{U}/^{238}\text{U}$ activity ratios..... | 135 |
| Chapter Five – Oxygen and Carbon isotopes | |
| 5.1 Introduction..... | 138 |
| 5.2 Standards..... | 138 |
| 5.2.1 Data..... | 138 |
| 5.2.2 Calibration of samples..... | 138 |
| 5.3 Background stable light isotope data..... | 140 |
| 5.3.1 Dolomite..... | 140 |
| 5.3.2 Flowstone..... | 141 |
| 5.3.3 Stalactites..... | 142 |
| 5.4 Western Face 1 samples..... | 144 |
| 5.4.1 Data..... | 144 |
| 5.4.2 Carbon Isotopes..... | 147 |
| 5.4.3 Oxygen Isotopes..... | 150 |
| Chapter Six – Discussion and conclusions | |
| 6.1 Introduction..... | 155 |
| 6.2 Morphology and sedimentology of the Pleistocene fill at Gladysvale Cave..... | 155 |
| 6.2.1 Three-dimensional sedimentary architecture of the cave fill fan..... | 155 |
| 6.2.2 Facies changes through space..... | 161 |
| 6.2.3 Facies changes through time..... | 162 |
| 6.3 Timing of flowstone growth at Gladysvale..... | 164 |
| 6.3.1 Comparison with the Tswaing Crater precipitation record..... | 166 |
| 6.3.2 Age model for undated flowstones..... | 166 |
| 6.3.3 Age model for intercalated breccias..... | 168 |
| 6.4 Climatic control of sedimentation at Gladysvale..... | 173 |
| 6.5 Chronostratigraphy and palaeoenvironmental synthesis for the Pleistocene fill at Gladysvale..... | 177 |
| 6.6 Comparison of Gladysvale with other climatic records..... | 185 |
| 6.6.1 The last 200 kyr..... | 185 |
| 6.6.2 The Last Glacial Maximum..... | 188 |
| 6.6.3 The Younger Dryas..... | 190 |
| 6.6.4 Major forcing mechanisms..... | 192 |
| 6.7 Climactically controlled cyclic model for sedimentation Gladysvale cave..... | 194 |
| 6.7.1 The Gladysvale Cave model..... | 194 |

| | Page |
|--|-------------|
| 6.7.2 Comparison of the Gladysvale model with published climatically controlled cave sedimentation models..... | 197 |
| 6.8 Conclusions..... | 199 |
| 7 References..... | 203 |
| 8 Appendix 1: Conference abstracts..... | 216 |