

# Contents

|                                                                                                                    |           |
|--------------------------------------------------------------------------------------------------------------------|-----------|
| Acknowledgements                                                                                                   | iv        |
| List of figures                                                                                                    | vi        |
| List of tables                                                                                                     | x         |
| <br>                                                                                                               |           |
| <b>1. Introduction</b>                                                                                             | <b>1</b>  |
| 1.1 Preamble .....                                                                                                 | 1         |
| 1.2 Motivation for the present study .....                                                                         | 4         |
| <br>                                                                                                               |           |
| <b>2. Geology of the Trans Himalaya in the Ladakh sector</b>                                                       | <b>8</b>  |
| 2.1 Geotectonic subdivisions of Himalaya .....                                                                     | 8         |
| 2.2 Subdivisions of Trans Himalaya .....                                                                           | 9         |
| 2.3 Geology of Ladakh .....                                                                                        | 9         |
| 2.3.1 General Introduction .....                                                                                   | 9         |
| 2.3.2 The passive continental margin deposits .....                                                                | 10        |
| 2.3.3 Indus Suture Zone .....                                                                                      | 10        |
| 2.3.4 Ladakh Batholith .....                                                                                       | 14        |
| 2.3.5 North of the Ladakh Batholith .....                                                                          | 14        |
| 2.4 Fieldwork and Samples .....                                                                                    | 16        |
| 2.4.1 Sabu-Leh-Khardung la- Hunder .....                                                                           | 16        |
| 2.4.1.1 Tirit-Diskit-Tegar-Panamik-Murgi ....                                                                      | 19        |
| 2.4.2 Kharu-Sakti-Chang la-Darbuk-Tangtse-Lukung ....                                                              | 20        |
| (Pangong Tso)                                                                                                      |           |
| 2.4.3 Shey-Thiksey-Upshi-Himia-Gaik-Kiari-Chumathang ....                                                          | 20        |
| 2.4.4 Mahe-Sumdo-Pugga-Polokangla-Tso Kar .....                                                                    | 22        |
| 2.4.5 Leh-Bodhkharbu-Shergol-Kargil-Dras .....                                                                     | 22        |
| 2.4.5.1 Hiniskut-Kanji-Yogma la- Nyigutse la-<br>Spongtag river .....                                              | 24        |
| <br>                                                                                                               |           |
| <b>3. <sup>40</sup>Ar-<sup>39</sup>Ar geochronology and thermochronology: theoretical and experimental aspects</b> | <b>28</b> |
| 3.1 Fundamentals .....                                                                                             | 28        |
| 3.1.1 Fundamental assumptions for K-Ar dating system ....                                                          | 29        |

|           |                                                              |    |
|-----------|--------------------------------------------------------------|----|
| 3.1.2     | $^{40}\text{Ar}$ - $^{39}\text{Ar}$ dating method .....      | 30 |
| 3.2       | $^{40}\text{Ar}$ - $^{39}\text{Ar}$ Thermochronology.....    | 32 |
| 3.2.1     | Diffusion theory and diffusion equation .....                | 33 |
| 3.2.2     | Arrhenius equation .....                                     | 33 |
| 3.2.3     | Concept of closure temperature and equation .....            | 35 |
| 3.2.4     | Assumptions .....                                            | 36 |
| 3.3       | Multi Diffusion Domain (MDD) model .....                     | 37 |
| 3.3.1     | Log( $r/r_0$ ) plot .....                                    | 37 |
| 3.4       | Experimental aspects .....                                   | 39 |
| 3.4.1     | Sample Preparation .....                                     | 39 |
| 3.4.2     | Irradiation of the Sample .....                              | 39 |
| 3.4.3     | Interfering nuclear reactions .....                          | 40 |
| 3.4.3.1   | Reactions with calcium .....                                 | 40 |
| 3.4.3.2   | Reaction with potassium .....                                | 41 |
| 3.4.4     | Decay correction .....                                       | 41 |
| 3.4.5     | The calculation of $^{40}\text{Ar}^*/^{39}\text{Ar}_k$ ..... | 42 |
| 3.4.6     | Argon extraction and purification .....                      | 43 |
| 3.4.7     | Analysis, Data acquisition and Reduction .....               | 46 |
| <b>4.</b> | <b>Results</b> .....                                         | 49 |
| 4.1       | Presentation of Results .....                                | 49 |
| 4.1.1     | Age spectrum and plateau age .....                           | 49 |
| 4.1.2     | Isochron plot .....                                          | 50 |
| 4.1.3     | Criterion of the Goodness of Fit .....                       | 50 |
| 4.2       | Monitor Sample .....                                         | 50 |
| 4.3       | Indus Suture Zone .....                                      | 52 |
| 4.4       | Dras Volcanics .....                                         | 54 |
| 4.5       | Ladakh Batholith .....                                       | 63 |
| 4.6       | North of the Ladakh Batholith .....                          | 72 |
| 4.6.1     | Shyok Suture Zone .....                                      | 72 |
| 4.6.2     | Karakoram Fault Zone.....                                    | 73 |
| 4.6.3     | Khardung Volcanics .....                                     | 92 |

|                                                                                                                                |            |
|--------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>5. Discussion</b>                                                                                                           | <b>103</b> |
| 5.1 Perspective.....                                                                                                           | 103        |
| 5.2 Indus Suture Zone .....                                                                                                    | 106        |
| 5.2.1 The ophiolitic mélange of Indus Suture Zone .....                                                                        | 106        |
| 5.2.2 Modeling the whole rock age spectra for basalts ...                                                                      | 107        |
| 5.3 The Ladakh batholith .....                                                                                                 | 109        |
| 5.3.1 Post-collision magma generation: partial re-melting<br>of batholith granitoids? .....                                    | 113        |
| 5.4 Northern Ladakh (North of the Ladakh batholith).....                                                                       | 114        |
| 5.4.1 Shyok Suture Zone .....                                                                                                  | 116        |
| 5.4.2 Khardung Volcanics .....                                                                                                 | 118        |
| 5.4.3 Simultaneous and independent evolution of the island and<br>continental arc along the southern margin of the Asian plate | 119        |
| 5.5 Conclusion .....                                                                                                           | 122        |
| <b>6. Evolution of the India-Asia collision zone in space and time:</b>                                                        |            |
| <b>A synthesis of thermochronological data</b>                                                                                 | <b>124</b> |
| 6.1 Introduction.....                                                                                                          | 124        |
| 6.2 Review of thermochronological data .....                                                                                   | 126        |
| 6.2.1 Thermochronology of Indus Suture .....                                                                                   | 126        |
| 6.2.2 Thermochronology of Trans Himalayan batholith ...                                                                        | 126        |
| 6.2.3 Thermochronology of north of the suture .....                                                                            | 128        |
| 6.2.4 Thermochronology of south of the suture .....                                                                            | 129        |
| 6.3 Propagation of deformation through time .....                                                                              | 129        |
| 6.4 Late accommodation of crust within the NW Trans Himalaya:                                                                  |            |
| Deformation in Shyok Suture Zone .....                                                                                         | 130        |
| 6.5 Scope for the further work .....                                                                                           | 132        |
| <b>References</b>                                                                                                              | <b>134</b> |