

## Foreword

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Received: 19 July 2010 / Accepted: 19 July 2010 / Published online: 25 August 2010  
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“Satellites of the Outer Solar System: Exchange Processes Involving the Interiors” is the second publication of its kind in the Space Science Series of ISSI. It is the result of a successful joint venture between ISSI and Europlanet.

Europlanet started in 2005, the year of the successful landing of the Huygens probe on Titan’s surface, as a network of over 110 European and U.S. laboratories deeply involved in the development of planetary sciences and the support to the European programme of space exploration of planets. Since 2005, Europlanet obtained support from the European Commission to strengthen the planetary science community worldwide, and to amplify the scientific output, impact and visibility of the European space programme, essentially ESA’s Horizon 2000 and Cosmic Vision programmes. Its first contract with the Commission, as a “Coordination action” extended from 2005 to 2008 and included 7 networking activities, among which the set-up of discipline working groups covering the main areas of planetary sciences. A new contract with the Commission, this time as a full “research infrastructure network”, extends Europlanet’s activities into the period 2009–2012. With the broad community connection made through its Discipline Working Groups and other activities, Europlanet offers an ideal base from which to identify new fields of research for planetary sciences and to stimulate collaborative work among its member laboratories. For Europlanet, developing collaboration with ISSI in holding workshops and producing books on these new and emerging subjects is both natural and extremely stimulating, considering the high profile, international standing and proven success of ISSI. For ISSI, collaboration with Europlanet offers a very interesting opportunity to extend its successful series of workshops and books within the area of planetary sciences and to deepen its links with this community.

Working from this clear convergence of interests, in 2006 ISSI and Europlanet initiated implementation of a series of joint workshops, soon after the establishment of Europlanet’s

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Discipline Working Groups. Each of Europlanet's nine Discipline Working Groups were invited to select one or two promising subjects for ISSI workshops, which were presented and discussed at a w.g. meeting at ESAC, Villafranca, Spain, April 24<sup>th</sup> to 26<sup>th</sup>. The Board of Coordinators of Europlanet then selected a shortlist. In the spring of 2007, the Science Committee of ISSI, chaired by Prof. Len Culhane, selected the proposal for a workshop on "Satellites of the Outer Solar System: Exchange Processes Involving the Interiors" formulated by Olivier Grasset, to become the second joint ISSI-Europlanet workshop.

This very timely choice indeed corresponds to a high priority and challenge of present-day space science. The successful survey of the Jupiter system by the Pioneer, Voyager and Galileo spacecraft in the XXth century, followed by the on-going detailed exploration of the Saturn system and its moons by Cassini-Huygens since 2004, have revealed to the science community and to the public at large the fascinating worlds of the moons of the outer planets. We are still going from surprise to surprise as new data unveil new aspects of their so complex characteristics: the discovery of gigantic geysers on Enceladus, and of the complex geological and meteorological activities at the surface of Titan, are the latest examples of a continuing series of breathtaking discoveries!

This book will provide the reader with an up-to-date view of what we know and understand to-day of the moons of outer planets: by their complexity, their internal differentiation, their geological or atmospheric activity, their still poorly known history and evolution, the largest of these moons at least are actual "planetary worlds", with all the complexity this term implies. In particular, and this is the aspect this book has chosen to emphasize, these bodies are complex evolving systems in which the interactions and chemical exchange processes between the different layers—from core to atmosphere or exosphere—play a key role. These interactions extend to the way they are partly driven by interactions with their central planet, via tidal interactions (which for some of them provide a substantial fraction of their internal heat source) and via interactions with their planet's magnetosphere.

One of the most outstanding features of some of these moons, those with a substantial fraction of water ice, is the generation and long-term maintenance of sub-surface water oceans. These oceans are natural candidates to be habitats for life. The question of their habitability, and therefore of the very possibility of the emergence of life in the outer solar system, has received increasing attention in the last decade or so, to the point that it is now one of the highest-priority challenges of astrobiology. If life can emerge there, far from the classical "habitable zone" of stars, then there may be many more places for life in the Universe, where giant planets systems are widespread, than we ever dared to imagine!

For this reason, and many more, understanding better the moons of outer planets, their origin, evolution and potential habitability has become a high priority of planetary exploration. This book builds on our present knowledge of these moons, inherited from telescope observations and past and present space missions, to provide the reader with a comprehensive view of what we understand and don't understand of these fascinating worlds. It also very nicely shows how current progress in this understanding builds on the interplay between three basic ingredients: new space and ground-based data, laboratory measurements of key parameters of the structural materials of these moons, and sophisticated models capable of integrating data and lab measurements into quantitative and predictive representations of planetary bodies, their different layers, and their interactions.

In line with the spirit of ISSI and Europlanet, it is on the basis of this continuing feedback loop between observations, laboratory measurements and modelling that future space missions can be designed and prepared, ultimately to provide a new set of observations that will bring our understanding of planetary moons further. Preparation for the next generation of missions to the outer planets has already begun: just four hundred year after their

discovery by Galileo Galilei, ESA and NASA are jointly preparing a new major step in the exploration of the Jovian moons, with the dual spacecraft EJSM-Laplace mission to the Jovian system; further on, the next logical steps will include a new mission to the Saturn system, deepening the discoveries of Cassini-Huygens with an in-depth investigation of Titan, its surface and atmosphere, and, further out, missions to the Ice Giants, Uranus and Neptune. Our exploration of the outer solar system has just started, and will take several decades to accomplish. No doubt it will unveil a fraction of the many mysteries of its fascinating planetary worlds: how they emerged from the cold outskirts of the solar nebula, how they formed complex differentiated bodies interacting with their environments and, possibly, how some of these bodies may have fulfilled the necessary conditions to develop and sustain life! This is, ultimately, the perspective that the reader will discover through the different chapters of this book.

In conclusion, we would like to thank all those whose hard work and dedication made this second joint publication of ISSI and Europlanet possible. Many thanks, first, to the leaderships of ISSI and Europlanet who designed this collaborative project, and to the leaders of the Discipline Working Groups of Europlanet, Norbert Krupp and Ari-Matti Harri. Many thanks to the Science Committee of ISSI, chaired by Prof. Len Culhane, who did the selection and made useful suggestions on the workshop content. Our special gratitude goes to Olivier Grasset, who originally proposed the workshop's topic and masterly led the whole process, from the first Conveners Meeting to book production. The team of conveners and editors did a fantastic job in defining the structure of the book and in managing the writing and the overall review process: as usual, all chapters were carefully reviewed by independent experts to whom we would also like to extend our gratitude.

Last, but not least, our warmest appreciation goes to the wonderful staff of ISSI, Andrea Fischer, ISSI's programme manager Vittorio Manno and his successor Maurizio Falanga, Saliba Saliba, Brigitte Schutte and Jennnifer Zaugg her successor, Irmela Schweizer, Silvia Wenger, and all their colleagues whose kindness and dedication make ISSI such a convivial and effective operation. They are the greatest asset on which this important collaboration between ISSI and Europlanet will continue to develop and flourish in the years to come.