



# **Creating a Practical Legal Framework for the Commercial Exploitation of Mineral Resources in Outer Space**

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**Ricky J. Lee**

# **Creating a Practical Legal Framework for the Commercial Exploitation of Mineral Resources in Outer Space**

**Ricky J. Lee**

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COMMERCIAL EXPLOITATION OF MINERAL RESOURCES IN OUTER SPACE**

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# CREATING A PRACTICAL LEGAL FRAMEWORK FOR THE COMMERCIAL EXPLOITATION OF MINERAL RESOURCES IN OUTER SPACE

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## ABSTRACT

*This thesis addresses the legal and policy issues relating to what may be the most exciting prospect in the history of the human civilisation: the commercial exploitation of natural resources in outer space. The thesis is based on the hypothesis that such ventures are inhibited not by physical, technological and economic factors, but by the inadequacies and uncertainties present in the current body of space law and policy. Consequently, a new international legal framework and a policy consensus are required to provide a legal environment favourable for such a valuable and necessary development.*

*To substantiate this hypothesis, the thesis begins by establishing the economic necessity and technical feasibility of space mining today, an estimate of the financial commitments required. This is followed by a risk analysis of a typical commercial mining venture in space, identifying the economic and legal risks. This leads to the recognition that the legal risks must be minimised to enable such enormous financial commitments to be made.*

*What then follows is a detailed analysis of the legal framework for such activities as well as identifying the inadequacies of space law for the commercial exploitation of celestial resources. This is achieved through a discussion of the general principles of international space law, particularly dealing with state responsibility and international liability, as well as some of the issues arising from space mining activities. Much detail is devoted to the analysis of the content of the “common heritage of mankind” doctrine in international law and the effect of international disagreement over its application to celestial bodies.*

*Having established the relevant legal issues, the thesis then turns to consider the past failures in reach similar agreements and the competing policy interests that have prevented the success of such agreements. It attempts to balance such interests in creating a legal and policy compromise that may be acceptable to a majority of the international community and provide some practical proposals on the structural, procedural, administrative and judicial aspects of creating and implementing a new legal framework.*

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**CREATING A PRACTICAL LEGAL FRAMEWORK FOR THE  
COMMERCIAL EXPLOITATION OF MINERAL RESOURCES IN OUTER SPACE**

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**DISCLAIMER**

*This thesis is the author's own account of his research and has not been submitted previously for any degree at any university or institution.*

*Further, to the best knowledge and belief of the author, this thesis contains no material previously published or written by another person other than the author except where due reference is made in the said thesis.*

*All views and opinions expressed or implied in this thesis are personally those of the author only and may not necessarily reflect those of any person or organisation with which the author is associated or affiliated.*

*The total word count of this thesis, excluding pages (i) to (xxxvii) and all headers, footers, footnotes, appendices, bibliography and the outline of contents at the beginning of each chapter but including all tables and captions, is 106,769 words.*

**DATED** on Friday, 4 December 2009.

*Ricky J. Lee*

**RICKY J. LEE**



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**GLOSSARY**

<b>TERM</b>	<b>MEANING</b>
<b>Absolute visual magnitude (<math>H</math>)</b>	A measure of a celestial body's intrinsic brightness, measured in the standard V photometric band.
<b>Amor Asteroid</b>	Asteroid with perihelion $1.017 \text{ AU} < q \leq 1.3 \text{ AU}$
<b>Aphelion (<math>Q</math>)</b>	The point on an orbit that is most distant from the Sun
<b>Apollo Asteroid</b>	Asteroid with perihelion $q < 1.017 \text{ AU}$ and semi major axis $a > 1.0 \text{ AU}$
<b>Arjuna Asteroid</b>	Asteroid with Earth-like orbits with low inclination, low eccentricity and orbital periods close to one Earth year
<b>Astronomical Unit (AU)</b>	Unit of length equal to the mean distance between the Earth and the Sun, estimated in 2009 at 149,597,870,700 metres.
<b>Aten Asteroid</b>	Asteroid with semi major axis $a < 1.0 \text{ AU}$ and aphelion $Q > 0.983 \text{ AU}$
<b>Carbonyl</b>	Compound of a metal with carbon monoxide (CO)
<b>Conjunction</b>	Where two objects are at the aphelion or perihelion at the same time
<b>Earth Minimum Orbital Intersection Distance (MOID)</b>	Minimum distance between closest points on the orbit of the Earth and the orbit of an asteroid or comet, usually given in astronomical units (AU). Potentially hazardous objects to the Earth have an Earth MOID of less than 0.05 AU.
<b>Eccentricity (<math>e</math>)</b>	Measure of the circularity of the orbit where the more eccentric an orbit, the more oval shaped the orbit is
<b>Ecliptic</b>	The orbital plane on which the Earth orbits the Sun
<b>Escape Velocity</b>	Minimum speed an object without propulsion needs to have to move away infinitely from the gravity of an object
<b>Hohmann Transfer Orbit</b>	Elliptical orbit that is tangential to two coplanar orbits that is most energy efficient transfer trajectory
<b>Hyperbolic Velocity</b>	The velocity ( $\Delta\vec{v}$ ) of an object relative to Earth or another celestial object when it is outside that body's gravity well
<b>Impulsive</b>	Change in velocity ( $\Delta\vec{v}$ ) that is given to an object in a short period of time relative to the total duration of the trajectory
<b>Inclination (<math>i</math>)</b>	The angle between the orbital plane of a particular object and the ecliptic
<b>Kerogen</b>	Solid hydrocarbons found in crude oil

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TERM	MEANING
<b>Opposition</b>	Where one object is at perihelion and the other is at aphelion
<b>Perihelion (<math>q</math>)</b>	The point on an orbit which is closest to the Sun
<b>Planetesimal</b>	One of a class of bodies that are theorised to have formed the planets after condensing from diffuse matter early in the history of the solar system
<b>Pyrolysis</b>	Generation of chemicals or free metals by heat decomposition
<b>Regolith</b>	The fragmented rocky debris blanketing the surface of the Moon, some asteroids and other small objects in the Solar System
<b>Semi-major Axis (<math>A</math>)</b>	The longest diameter of an elliptical orbit.
<b>Synodic Period</b>	Period of a body relative to the Earth
<b>Transfer Orbit</b>	The trajectory for an object travelling from one body to another
<b>Trojan</b>	An object which is trapped in a stable orbit $60^\circ$ ahead of or behind the object as it orbits the Sun
<b>Volatiles</b>	Gases that can be released from comet cores by heating, producing gases such as water, carbon dioxide ( $\text{CO}_2$ ), carbon monoxide ( $\text{CO}$ ), methane ( $\text{CH}_4$ ), ammonia ( $\text{NH}_3$ ) and hydrogen cyanide ( $\text{HCN}$ )

## CREATING A PRACTICAL LEGAL FRAMEWORK FOR THE COMMERCIAL EXPLOITATION OF MINERAL RESOURCES IN OUTER SPACE

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### TABLE OF ABBREVIATIONS

TERM	DEFINITION
<b>AAS</b>	American Astronomical Society
<b>ACP</b>	African, Caribbean and Pacific Group of States
<b>AIAA</b>	American Institute of Aeronautics and Astronautics
<b>AN</b>	Ascending node
<b>ARABSAT</b>	Arab Corporation for Space Communications
<b>AU</b>	Astronomical Unit
<b>COPUOS</b>	Committee on Peaceful Uses of Outer Space
<b>COSPAR</b>	Committee on Space Research
<b>DN</b>	Descending node
<b>ECAS</b>	Eight Colour Asteroid Survey
<b>ECSL</b>	European Centre for Space Law
<b>EEC</b>	European Economic Community
<b>ENPV</b>	Expected Net Present Value
<b>ESA</b>	European Space Agency
<b>EUMETSAT</b>	European Organisation for the Exploitation of Meteorological Satellites
<b>EUTELSAT</b>	European Telecommunication Satellite Organisation
<b>GATT</b>	General Agreement on Tariffs and Trade
<b>GEO</b>	Geostationary Earth Orbit
<b>HEEO</b>	Highly Elliptical Earth Orbit
<b>IAU</b>	International Astronomical Union
<b>IBA</b>	International Bar Association
<b>IBRD</b>	International Bank for Reconstruction and Development
<b>ICC</b>	International Chamber of Commerce
<b>IISL</b>	International Institute of Space Law
<b>ILC</b>	International Law Commission
<b>IMF</b>	International Monetary Fund
<b>INMARSAT</b>	International Mobile Satellite Organisation



<b>TERM</b>	<b>DEFINITION</b>
<b>INTELSAT</b>	International Telecommunication Satellite Organisation
<b>ISA</b>	International Seabed Authority
<b>ISRO</b>	Indian Space Research Organisation
<b>ITLOS</b>	International Tribunal for the Law of the Sea
<b>ITU</b>	International Telecommunication Union
<b>LEO</b>	Low Earth Orbit
<b>NASA</b>	National Aeronautics and Space Administration
<b>NEAR</b>	Near Earth Asteroid Rendezvous
<b>NIEO</b>	New International Economic Order
<b>NPV</b>	Net Present Value
<b>OPEC</b>	Organisation of Petroleum Exporting Countries
<b>RLV</b>	Reusable Launch Vehicle
<b>ROI</b>	Return on Investment
<b>SSI</b>	Space Studies Institute
<b>SSPS</b>	Space Solar Power Satellite
<b>UN</b>	United Nations
<b>UNCLOS III</b>	Third United Nations Conference on the Law of the Sea
<b>UNCTAD</b>	United Nations Conference on Trade and Development
<b>UNESCO</b>	United Nations Education, Scientific and Cultural Organisation
<b>UNIDROIT</b>	International Institute for the Unification of Private Law
<b>USA</b>	United States of America
<b>USACERL</b>	United States Army Construction Engineering Research Laboratory
<b>WIPO</b>	World Intellectual Property Organisation
<b>WTO</b>	World Trade Organisation

**CREATING A PRACTICAL LEGAL FRAMEWORK FOR THE  
COMMERCIAL EXPLOITATION OF MINERAL RESOURCES IN OUTER SPACE**

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**TABLE OF REPORTS, SERIES AND JOURNAL TITLES**

<b>SOURCE</b>	<b>FULL TITLE</b>
<b>A. F. L. Rev.</b>	Air Force Law Review
<b>A.S.I.L.S. Int'l. L. J.</b>	Association of Student International Law Societies International Law Journal
<b>A.T.S.</b>	Australian Treaty Series
<b>Abs. Lunar &amp; Planetary Sci. Conf.</b>	Abstracts of the Lunar and Planetary Science Conference
<b>Acta Astron.</b>	Acta Astronautica (Journal of the International Academy of Astronautics)
<b>Acta Juridica</b>	Acta Juridica (Law Journal of the University of Cape Town)
<b>Ad Astra</b>	Ad Astra (Journal of the National Space Society)
<b>Adel. L. Rev.</b>	Adelaide Law Review
<b>Adv. Space Res.</b>	Advanced Space Research
<b>Air &amp; Sp. L.</b>	Air & Space Law
<b>Akron L. Rev.</b>	Akron Law Review
<b>Am. J. Int'l. L.</b>	American Journal of International Law
<b>Am. J. Int'l. L. Supp.</b>	American Journal of International Law Supplement
<b>Am. Soc. Int'l. L. Proc.</b>	Proceedings of the American Society of International Law
<b>Am. U. J. Int'l. L. &amp; Pol'y.</b>	American University Journal of International Law and Policy
<b>Am. U. L. Rev.</b>	American University Law Review
<b>Ann. Air &amp; Sp. L.</b>	Annals of Air and Space Law
<b>Ann. Assoc. Am. Geog.</b>	Annals of the Association of American Geographers
<b>Ann. Rev. Astron. &amp; Astrop.</b>	Annual Review of Astronomy and Astrophysics
<b>Ann. Rev. Energy</b>	Annual Review of Energy
<b>App. Geog.</b>	Applied Geography
<b>Astron. &amp; Astrophys.</b>	Astronomy and Astrophysics

SOURCE	FULL TITLE
<b>Astron. Gesell. Abs. Ser.</b>	Astronomische Gesellschaft Abstract Series (Astronomical Society Abstract Series)
<b>Astron. J.</b>	Astronomical Journal
<b>Astrophysics J.</b>	Astrophysics Journal
<b>Aust. Int'l. L. J.</b>	Australian International Law Journal
<b>Aust. J. Astron.</b>	Australian Journal of Astronomy
<b>Aust. Y. B. Int'l. L.</b>	Australian Yearbook of International Law
<b>Az. J. Int'l. &amp; Comp. L.</b>	Arizona Journal of International and Comparative Law
<b>B. C. Env'tl. Aff. L. Rev.</b>	Boston College Environmental Affairs Law Review
<b>B. C. Int'l. &amp; Comp. L. Rev.</b>	Boston College International and Comparative Law Review
<b>B. U. Int'l. L. J.</b>	Boston University International Law Journal
<b>Baylor L. Rev.</b>	Baylor Law Review
<b>Berkeley Tech. L. J.</b>	Berkeley Technology Law Journal
<b>Brit. Y. B. Int'l. L.</b>	British Yearbook of International Law
<b>Brooklyn J. Int'l. L.</b>	Brooklyn Journal of International Law
<b>Brooklyn L. Rev.</b>	Brooklyn Law Review
<b>Buff. L. Rev.</b>	Buffalo Law Review
<b>Bull. Am. Astron. Soc.</b>	Bulletin of the American Astronomical Society
<b>C.F.R.</b>	Code of Federal Regulations
<b>Cable News Network</b>	Cable News Network
<b>Cal. L. Rev.</b>	California Law Review
<b>Cal. W. Int'l. L. J.</b>	California Western International Law Journal
<b>Cam. L. J.</b>	Cambridge Law Journal
<b>Can. Y. B. Int'l. L.</b>	Canadian Yearbook of International Law
<b>Cardozo L. Rev.</b>	Cardozo Law Review
<b>Case W. Res. J. Int'l. L.</b>	Case Western Reserve Journal of International Law
<b>Chi. J. Int'l. L.</b>	Chinese Journal of International Law
<b>Colo. J. Int'l. Env'tl. L. &amp; Pol'y.</b>	Colorado Journal of International Environmental Law and Policy
<b>Colum. J. Env'tl. L.</b>	Columbia Journal of Environmental Law
<b>Colum. J. Transnat'l. L.</b>	Columbia Journal of Transnational Law
<b>Colum. J. World Bus.</b>	Columbia Journal of World Business

<b>SOURCE</b>	<b>FULL TITLE</b>
<b>Colum. L. Rev.</b>	Columbia Law Review
<b>Com. L. J.</b>	Commercial Law Journal
<b>Conn. J. Int'l. L.</b>	Connecticut Journal of International Law
<b>Cornell Int'l. L. J.</b>	Cornell International Law Journal
<b>Cornell L. Rev.</b>	Cornell Law Review
<b>Cosmic Research</b>	Cosmic Research
<b>Crosslink</b>	Crosslink
<b>De Economist</b>	De Economist
<b>Def. Sci.</b>	Defence Science
<b>Denver J. Int'l. L. &amp; Pol'y.</b>	Denver Journal of International Law and Policy
<b>Detroit Coll. L. J. Int'l. L. &amp; Prac.</b>	Detroit College of Law Journal of International Law and Practice
<b>Dick. J. Int'l. L.</b>	Dickenson Journal of International Law
<b>Die Friedenswarte</b>	Die Friedenswarte
<b>E.R.</b>	English Reports
<b>Earth Planets &amp; Sp.</b>	Earth Planets and Space
<b>Earth, Moon &amp; Planets</b>	Earth, Moon and Planets
<b>Ec. &amp; Fin. Rev.</b>	Economics and Finance Review
<b>Ecology L. Q.</b>	Ecology Law Quarterly
<b>Econ. J.</b>	Economics Journal
<b>Emory Int'l. L. Rev.</b>	Emory International Law Review
<b>Emory J. Int'l. Disp. Resol.</b>	Emory Journal of International Dispute Resolution
<b>Energy Explor. &amp; Exploit.</b>	Energy Exploration and Exploitation
<b>Energy Policy</b>	Energy Policy
<b>Env'tl. &amp; Res. Ec.</b>	Environmental and Resource Economics
<b>Env'tl. L.</b>	Environmental Law
<b>Eur. J. Int'l. L.</b>	European Journal of International Law
<b>Fl. Coastal L. Rev.</b>	Florida Coastal Law Review
<b>Fl. Int'l. L. J.</b>	Florida International Law Journal
<b>Fordham Env'tl. L. Rep.</b>	Fordham Environmental Law Report
<b>Fordham L. Rev.</b>	Fordham Law Review
<b>Foreign Aff.</b>	Foreign Affairs

<b>SOURCE</b>	<b>FULL TITLE</b>
<b>Foreign Policy</b>	Foreign Policy
<b>Foreign Service J.</b>	Foreign Service Journal
<b>Ga. J. Int'l. &amp; Comp. L.</b>	Georgia Journal of International and Comparative Law
<b>Geo. Wash. J. Int'l. L. &amp; Ec.</b>	George Washington Journal of International Law and Economics
<b>Geoadria</b>	Geoadria
<b>Geochim. &amp; Cosmochim. Acta</b>	Geochimica et Cosmochimica Acta (Journal of the Geochemical and Meteoritical Societies)
<b>Georgetown Int'l. Env't'l. L. Rev.</b>	Georgetown International Environmental Law Review
<b>Georgetown L. J.</b>	Georgetown Law Journal
<b>Hague Y. B. Int'l. L.</b>	Hague Yearbook of International Law
<b>Harv. Int'l. L. J.</b>	Harvard International Law Journal
<b>Harv. J. Law &amp; Tech.</b>	Harvard Journal of Law and Technology
<b>Harv. J. on Legis.</b>	Harvard Journal on Legislation
<b>Hastings Int'l. &amp; Comp. L. Rev.</b>	Hastings International and Comparative Law Review
<b>Hastings L. J.</b>	Hastings Law Journal
<b>Herts. L. J.</b>	Hertfordshire Law Journal
<b>Hist. &amp; Tech.</b>	History and Technology
<b>Houston J. Int'l. L.</b>	Houston Journal of International Law
<b>Howard L. J.</b>	Howard Law Journal
<b>Human Rights Q.</b>	Human Rights Quarterly
<b>Hyperfine Interactions</b>	Hyperfine Interactions
<b>I.C.J. Rep.</b>	Reports of the International Court of Justice
<b>I.L.M.</b>	International Legal Materials
<b>I.L.R.</b>	International Law Reports
<b>Icarus</b>	Icarus
<b>Ind. J. Global Legal Stud.</b>	Indiana Journal of Global Legal Studies
<b>Ind. Leg. F.</b>	Indiana Legal Forum
<b>Indian J. Int'l. L.</b>	Indian Journal of International Law
<b>Info. Econ. &amp; Pol'y.</b>	Information Economics and Policy
<b>Int'l. &amp; Comp. L. Q.</b>	International and Comparative Law Quarterly

SOURCE	FULL TITLE
<b>Int'l. Bus. Lawyer</b>	International Business Lawyer
<b>Int'l. Geol. Rev.</b>	International Geology Review
<b>Int'l. J.</b>	International Journal
<b>Int'l. J. Estuarine &amp; Coastal L.</b>	International Journal of Estuarine and Coastal Law
<b>Int'l. J. Marine &amp; Coastal L.</b>	International Journal of Marine and Coastal Law
<b>Int'l. Lawyer</b>	International Lawyer
<b>Int'l. Leg. Persp.</b>	International Legal Perspectives
<b>Int'l. Org.</b>	International Organisations
<b>Int'l. R. &amp; S. Ab.</b>	Internationalrechtliche und staatrechtliche Abhandlungen
<b>Int'l. Trade L. J.</b>	International Trade Law Journal
<b>Iran-U.S.C.T.R.</b>	Iran-U.S. Claims Tribunal Reports
<b>Isr. L. Rev.</b>	Israel Law Review
<b>J. Afr. L.</b>	Journal of African Law
<b>J. Air L. &amp; Com.</b>	Journal of Air Law and Commerce
<b>J. Astron. &amp; Space Sci.</b>	Journal of Astronomy and Space Science
<b>J. Brit. Interplanetary Soc.</b>	Journal of the British Interplanetary Society
<b>J. Contemp. Leg. Issues</b>	Journal of Contemporary Legal Issues
<b>J. Energy Nat. Res. L.</b>	Journal of Energy and Natural Resources Law
<b>J. Env'tl. L. &amp; Lit.</b>	Journal of Environmental Law and Litigation
<b>J. Geophys. Res.</b>	Journal of Geophysical Research
<b>J. Guid. Con. &amp; Dyn.</b>	Journal of Guidance, Control and Dynamics
<b>J. Hist. Int'l. L.</b>	Journal of the History of International Law
<b>J. Int'l. L. &amp; Bus.</b>	Journal of International Law and Business
<b>J. Japan &amp; Int'l. Econ.</b>	Journal of Japanese and International Economics
<b>J. L. &amp; Env't.</b>	Journal of Law and Environment
<b>J. Land Use &amp; Env'tl. L.</b>	Journal of Land Use and Environmental Law
<b>J. Legis.</b>	Journal of Legislation
<b>J. Marit. L. &amp; Com.</b>	Journal of Maritime Law and Commerce
<b>J. Nat. Res. &amp; Env'tl. L.</b>	Journal of Natural Resources and Environmental Law
<b>J. Pat. Off. Soc'y.</b>	Journal of the Patent Office Society
<b>J. Pol. Econ.</b>	Journal of Political Economy

SOURCE	FULL TITLE
<b>J. Policy Modelling</b>	Journal of Policy Modelling
<b>J. Pub. Pol’y.</b>	Journal of Public Policy
<b>J. Royal Soc. Arts</b>	Journal of the Royal Society for the Arts
<b>J. Sp. L.</b>	Journal of Space Law
<b>J. Spacecraft &amp; Rockets</b>	Journal of Spacecraft and Rockets
<b>J. World Trade L.</b>	Journal of World Trade Law
<b>Kyklos</b>	Kyklos
<b>L. &amp; Contemp. Probs.</b>	Law and Contemporary Legal Problems
<b>L. &amp; Pol’y. Int’l. Bus.</b>	Law and Policy in International Business
<b>L. Q. Rev.</b>	Law Quarterly Review
<b>L.N.T.S.</b>	League of Nations Treaty Series
<b>La. L. Rev.</b>	Louisiana Law Review
<b>Lawyer Am.</b>	Lawyer of the Americas
<b>Leiden J. Int’l. L.</b>	Leiden Journal of International Law
<b>Loyola L. A. Int’l. &amp; Comp. L. Ann.</b>	Loyola of Los Angeles International and Comparative Law Annals
<b>Loyola L. A. Int’l. &amp; Comp. L. J.</b>	Loyola of Los Angeles International and Comparative Law Journal
<b>Loyola U. Chi. L. J.</b>	Loyola University Law Journal
<b>Lunar Planet. Sci.</b>	Proceedings of the Lunar and Planetary Science Conference
<b>Malaya L. Rev.</b>	Malaya Law Review
<b>Man. J. Int’l. Econ. L.</b>	Manchester Journal of International Economic Law
<b>Max Planck U.N.Y.B.</b>	Max Planck Yearbook of United Nations Law
<b>Melb. J. Int’l. L.</b>	Melbourne Journal of International Law
<b>Meteor. &amp; Planet. Sci.</b>	Meteoritics and Planetary Sciences
<b>Meteoritics</b>	Meteoritics
<b>Mich. J. Int’l. L.</b>	Michigan Journal of International Law
<b>Mill. J. Int’l. Stud.</b>	Millennium Journal of International Studies
<b>Mo. Env’tl. L. &amp; Pol’y. Rev.</b>	Missouri Environmental Law and Policy Review
<b>Monash U. L. Rev.</b>	Monash University Law Review
<b>Mq. J. Int’l. &amp; Comp. Env’tl. L.</b>	Macquarie Journal of International and Comparative Environmental Law
<b>Murdoch U. Elec. J. L.</b>	Murdoch University Electronic Journal of Law

SOURCE	FULL TITLE
<b>N. C. J. Int'l. L. &amp; Com. Reg.</b>	North Carolina Journal of International Law and Commercial Regulation
<b>N. Ir. Leg. Q.</b>	Northern Ireland Legal Quarterly
<b>N. Y. J. Int'l. &amp; Comp. L.</b>	New York Journal of International and Comparative Law
<b>N. Y. U. Env't'l. L. J.</b>	New York University Environmental Law Journal
<b>N. Y. U. J. Int'l. L. &amp; Pol.</b>	New York University Journal of International Law and Policy
<b>N. Z. J. Env't'l. L.</b>	New Zealand Journal of Environmental Law
<b>Nat. Res. J.</b>	Natural Resources Journal
<b>Nat. Res. Lawyer</b>	Natural Resources Lawyer
<b>Nature</b>	Nature
<b>Naval L. Rev.</b>	Naval Law Review
<b>Naval L. Rev.</b>	Naval Law Review
<b>Ned. Tijds. Int'l. Recht</b>	Nederlands Tijdschrift voor Internationaal Recht (Netherlands Journal of International Law)
<b>New Scientist</b>	New Scientist
<b>Nordisk Tids. Int'l. Ret. Nordic J. Int'l. L.</b>	Nordisk Tidsskrift for International Ret (Nordic Journal of International Law)
<b>Notre Dame. Int'l. &amp; Comp. L. J.</b>	Notre Dame International and Comparative Law Journal
<b>Nw. J. Int'l. L. &amp; Bus.</b>	Northwestern Journal of International Law and Business
<b>O.J.</b>	Official Journal of the European Union
<b>Ocean &amp; Coastal L. J.</b>	Ocean and Coastal Law Journal
<b>Ocean Dev. &amp; Int'l. L. J.</b>	Ocean Development and International Law Journal
<b>Operations Research</b>	Operations Research
<b>Or. L. Rev.</b>	Oregon Law Review
<b>Organisational Dynamics</b>	Organisational Dynamics
<b>Osgoode Hall L. J.</b>	Osgoode Hall Law Journal
<b>Ottawa L. Rev.</b>	Ottawa Law Review
<b>P.C.I.J. Rep.</b>	Permanent Court of International Justice Reports
<b>Past &amp; Present</b>	Past and Present
<b>Pepp. L. Rev.</b>	Pepperdine Law Review
<b>Phys. Rev. Letters</b>	Physics Review Letters



<b>SOURCE</b>	<b>FULL TITLE</b>
<b>Physics Edu.</b>	Physics Education
<b>Planet. Sp. Sci.</b>	Planetary and Space Science
<b>Polar Rec.</b>	Polar Record
<b>Proc. Coll. L. Outer Sp.</b>	Proceedings of the Colloquium on the Law of Outer Space (from 2008: Proceedings of the International Institute of Space Law)
<b>Pub. L. Forum</b>	Public Law Forum
<b>R.I.A.A.</b>	Reports of International Arbitral Awards
<b>Regent J. Int'l. L.</b>	Regent Journal of International Law
<b>Rev. Aca. Colom. Juris.</b>	Revista de la Academia Colombiana de Jurisprudencia (Colombian Academy of Law Review)
<b>Rev. Cen. Inv. Dif. Aero. Esp.</b>	Revista del Centro de Investigación y Difusión Aeronáutico-Espacial (Journal of the Centre for Aeronautics and Space Research and Outreach)
<b>Rev. Jur. U. P. R.</b>	Revista Juridica de la Universidad de Puerto Rico (University of Puerto Rico Law Review)
<b>Rev. World Econ.</b>	Review of World Economics
<b>Revue Gén. Dr.</b>	Revue Générale de Droit (General Law Review)
<b>Revue Gén. Dr. Int'l. Pub.</b>	Revue Générale de Droit International Public (General Public International Law Review)
<b>Rich. J. Global L. &amp; Bus.</b>	Richmond Journal of Global Law and Business
<b>Rutgers L. J.</b>	Rutgers Law Journal
<b>S. Afr. L. J.</b>	South African Law Journal
<b>S. Cal. L. Rev.</b>	Southern California Law Review
<b>S. Tex. L. Rev.</b>	South Texas Law Review
<b>San Diego L. Rev.</b>	San Diego Law Review
<b>Santa Clara Computer &amp; High Tech. L. J.</b>	Santa Clara Computer and High Technology Law Journal
<b>Scand. J. Econ.</b>	Scandinavian Journal of Economics
<b>Science</b>	Science
<b>Scientific American</b>	Scientific American
<b>Seton Hall L. Rev.</b>	Seton Hall Law Review
<b>Singapore J. Int'l. &amp; Comp. L.</b>	Singapore Journal of International and Comparative Law (from 2005: Singapore Yearbook of International Law)

<b>SOURCE</b>	<b>FULL TITLE</b>
<b>Solar Energy</b>	Solar Energy
<b>Solar System Dev. J.</b>	Solar System Development Journal
<b>Space News</b>	Space News
<b>Space Power</b>	Space Power
<b>Space Sci. Rev.</b>	Space Science Review
<b>Sri Lanka J. Int'l. L.</b>	Sri Lanka Journal of International Law
<b>St. John's L. Rev.</b>	St. John's Law Review
<b>St. Thom. L. Rev.</b>	St. Thomas Law Review
<b>Stanford J. Int'l. L.</b>	Stanford Journal of International Law
<b>Stanford J. Int'l. Stud.</b>	Stanford Journal of International Studies
<b>Stud. Transnat'l. Leg. Pol'y.</b>	Studies in Transnational Legal Policy
<b>Suffolk Transnat'l. L. J.</b>	Suffolk Transnational Law Journal
<b>Syracuse J. Int'l. L.</b>	Syracuse Journal of International Law
<b>Syracuse J. Int'l. L. &amp; Com.</b>	Syracuse Journal of International Law and Commerce
<b>T.I.A.S.</b>	Treaties and Other International Acts Series
<b>Temple Int'l. &amp; Comp. L. J.</b>	Temple International and Comparative Law Journal
<b>Tex. Int'l. L. F.</b>	Texas International Law Forum
<b>The Astro. J.</b>	The Astronomy Journal
<b>The Economist</b>	The Economist
<b>The Forum</b>	The Forum
<b>The Telegraph</b>	The Telegraph (United Kingdom)
<b>Third World Leg. Stud.</b>	Third World Legal Studies
<b>Tourism Man.</b>	Tourism Management
<b>Tul. L. Rev.</b>	Tulane Law Review
<b>Tulsa J. Comp. &amp; Int'l. L.</b>	Tulsa Journal of Comparative and International Law
<b>Tulsa L. J.</b>	Tulsa Law Journal
<b>Tx. Int'l. L. J.</b>	Texas International Law Journal
<b>U. Dayton L. Rev.</b>	University of Dayton Law Review
<b>U. Det. L. J.</b>	University of Detroit Law Journal
<b>U. Fla. L. Rev.</b>	University of Florida Law Review
<b>U. Ill. L. F.</b>	University of Illinois Law Forum
<b>U. Miami L. Rev.</b>	University of Miami Law Review

<b>SOURCE</b>	<b>FULL TITLE</b>
<b>U. N. B. L. J.</b>	University of New Brunswick Law Journal
<b>U. Qld. L. J.</b>	University of Queensland Law Journal
<b>U. S. F. L. Rev.</b>	University of San Francisco Law Review
<b>U.C.L.A. L. Rev.</b>	University of California Los Angeles Law Review
<b>U.K.T.S.</b>	United Kingdom Treaty Series
<b>U.M.K.C. L. Rev.</b>	University of Missouri Kansas City Law Review
<b>U.N.T.S.</b>	United Nations Treaty Series
<b>U.S.</b>	United States Law Reports
<b>U.S.A.F.A. J. Leg. Stud.</b>	United States Air Force Academy Journal of Legal Studies
<b>U.S.C.</b>	United States Code
<b>U.S.D.I.L.</b>	Digest of U.S. Practice in International Law
<b>U.S.T.</b>	United States Treaties and Other Documents
<b>Uni. Toronto L. J.</b>	University of Toronto Law Journal
<b>Va. Env'tl. L. J.</b>	Virginia Environmental Law Journal
<b>Va. J. Int'l. L.</b>	Virginia Journal of International Law
<b>Va. L. Rev.</b>	Virginia Law Review
<b>Vand. J. Transnat'l. L.</b>	Vanderbilt Journal of Transnational Law
<b>Wash. &amp; Lee L. Rev.</b>	Washington and Lee Law Review
<b>Wis. Int'l. L. J.</b>	Wisconsin International Law Journal
<b>Wm. &amp; Mary L. Rev.</b>	William and Mary Law Review
<b>World Dev.</b>	World Development
<b>Y. B. World Aff.</b>	Yearbook of World Affairs
<b>Y.B.I.L.C.</b>	Yearbook of the International Law Commission
<b>Yale L. &amp; Pol'y. Rev.</b>	Yale Law and Policy Review
<b>Yale Stud. World Pub. Ord.</b>	Yale Studies in World Public Order
<b>Zeit. Aus. Recht. Völk.</b>	Zeitschrift für ausländisches öffentliches Recht und Völkerrecht (Heidelberg Journal of International Law)
<b>Zeit. Luft. Welt.</b>	Zeitschrift für Luft- und Weltraumrecht (German Journal of Air and Space Law)

# CREATING A PRACTICAL LEGAL FRAMEWORK FOR THE COMMERCIAL EXPLOITATION OF MINERAL RESOURCES IN OUTER SPACE

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## ACKNOWLEDGEMENTS

From the early moments of my interest in space law, the concept of prospecting, extracting and exploiting natural resources on the Moon and other celestial bodies in the Solar System has always fascinated me and captured my imagination. After all, this is not exactly pure fantasy. Scientists and entrepreneurs have all dreamt of a world and a time where humankind has established itself in the far-reaching corners of this our own galaxy. At the same time, economists and environmentalists have all heralded the coming of a time when mineral resources on Earth are depleted and led us to imagine the remnants of the ruined planet that would remain from our quest for more resources. It must be clear that the future of human civilisation must lie in outer space and exploitation of mineral resources must be a part of these developments.

Consequently, if space lawyers are motivated by a desire to contribute to the building of the solid legal foundations necessary for this future advancement and expansion of human civilisation into outer space, then the law for space mining must be one of the fundamental issues that must be resolved. The absence of a legal framework for regulating human extraction and exploitation of mineral resources from celestial bodies may result in such ventures disregarding their effects on international economics, the space environment, social needs and long-term sustainability, all in the pursuit of short-term wealth and profit. This would resemble a lawless realm not unlike the USA in the days of Manifest Destiny. Indeed, one prominent legal scholar once suggested to me in a private discussion that a space law principle similar to the *Homestead Act*, whereby settlers are granted land ownership after “working” and “living off” the land for seven years, may be workable when applied to celestial bodies.

Creating a legal framework for future mining activities in space may not be a pressing priority today but must be one tomorrow, for the day after tomorrow may be too late.

The field of space law appealed to me originally as a convenient combination of my casual interest in space and my legal studies. Over the years, however, it grew from a peripheral interest to become a passion and from that passion grew a career path that has been both challenging and rewarding. I still recall that one Thursday afternoon in 1998 at the University of Adelaide when I was at lunchtime seminar on space law and its opportunities presented by Michael E. Davis, a partner at the Adelaide law firm of Adelta Legal. From that time, not content with having introduced me to this new and exciting field of law, Mr. Davis soon became my employer and continues to be an invaluable support, mentor and friend. Mere written words are never enough to express my gratitude to him for all that he has done for me, but I offer them here nonetheless as a very small token of my thanks.

In late 1999, after I was elected a member of the International Institute of Space Law and have volunteered to develop the Asia Pacific Regional Rounds of the Manfred Lachs Space Law Moot Court Competition, Mr. Davis introduced me to the late Associate Professor Alexis Goh of the University of Western Sydney as a useful contact in that endeavour. After I moved to Canberra from Adelaide in 2000, she encouraged me to undertake this thesis at the University of Western Sydney and she herself became my extremely supportive doctoral supervisor. She had shown tremendous faith and high expectations in my abilities as a doctoral candidate and as a teaching academic, both of which I have tried over the years to meet as much as I can though in truth I know I probably can never meet. She was a generous and understanding boss, an encouraging but critical supervisor, a resourceful and supportive friend without whom this thesis (and my academic career) would never have become a reality. She is much missed.

My thanks go to Associate Professor Vernon Nase, City University of Hong Kong, who kindly agreed to become my supervisor and has peppered me with critical yet invaluable comments and suggestions on this thesis and allowed for its completion. I am much indebted to him for the kindness and friendship that he has shown to me, both as my doctoral supervisor and generally in the field of space law.

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I would also like to thank the School of Law of Murdoch University and previously the School of Law of the University of Western Sydney for allowing me the opportunity to undertake this doctoral thesis and supporting me in this endeavour. My thanks also go to Mark Sonter, director of Asteroid Enterprises Pty Ltd, who provided me with some of his expert insights into the physical and technical aspects of mining asteroids.

It goes without saying, though worth saying nonetheless, that without the continuing support encouragement and love of my family, I can achieve nothing in my life. I am very grateful, even though I may not appear to show it from time to time.

Of course, all faults and shortcomings in this thesis are solely and exclusively my own.

*Ricky J. Lee*

**Ricky J. Lee**

Sydney, Australia

Friday, 4 December 2009

*Dedicated to the Memory of  
Associate Professor Alexis Goh*



In a closed society Malthusianism has the appearance of self-evident truth, and herein lies the danger. It is not enough to argue against Malthusianism in the abstract - such debates are not settled in academic journals. Unless people can see broad vistas of unused resources in front of them, the belief in limited resources tends to follow as a matter of course. And if the idea is accepted that the world's resources are fixed, then each person is ultimately the enemy of every other person, and each race or nation is the enemy of every other race or nation. The extreme result is tyranny, war and even genocide. Only in a universe of unlimited resources can all men be brothers.

— Robert Zubrin and Richard Wagner\*

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\* Robert Zubrin and Richard Wagner, *THE CASE FOR MARS: THE PLAN TO SETTLE THE RED PLANET AND WHY WE MUST* (1997), at 303.