Water On The Moon Essay, Research Paper

Abstract The Pentagon announced on December 3rd, 1996 that dataacquired by the Clementine spacecraft indicates that thereis ice in the bottom of a crater on the Moon. Located onthe Moon’s South Pole it was discovered with radar data. Introduction “The Deep Space Program Science Experiment (DSPSE), thefirst of a series of Clementine technology demonstrationsjointly sponsored by the Ballistic Missile DefenseOrganization (BMDO) and the National Aeronautics and SpaceAdministration (NASA), launched in early 1994. It’sprinciple objective is to space qualify lightweight imagingsensors and component technologies for the next generationof Department of Defense (DoD) spacecraft.” (Sweeney, 1998) The Clementine mission uses the Moon, a neat-Earth asteroid,and the spacecraft’s Interstage Adapter (ISA) as targets todemonstrate lightweight component and sensor performance. As a secondary mission, Clementine returns valuable data ofinterest to the international civilian scientific sector. It represents a new class of small, low cost, and highlycapable spacecraft that fully embrace emerging lightweighttechnologies to enable a series of long duration deep spacemissions. Background: The Clementine Spacecraft:The BDMO assignedresponsibility for the Clementine spacecraft design,manufacture, integration, and mission execution to the NavalResearch Laboratory (NRL). Clementine launched on a TitanIIG expendable launch vehicle from Vandenburg Air Force Baseinto Low Earth Orbit in January 1994. During its two monthorbit of the Moon it captured 1.8 million images of theMoons surface. The Lunar Prospector:After the discovery of thepossibility of water on the moon, programs such as NASA andDSPSE began work on an extensive project called the LunarProspector. The Lunar Prospector is designed for low polarorbit investigation of the Moon, including mapping ofsurface composition and possible polar ice deposits,measurements of magnetic and gravity fields, and study oflunar outgassing events. Data from the 1 to 3 year missionwill allow construction of a detailed map of the surfacecomposition of the Moon, and will improve our understandingof the origin, evolution, current state, and resources ofthe Moon. The spacecraft is a graphite-epoxy drum, 1.4meters in diameter and 1.22 meters high with three radialinstrument booms. There is no on-board computer, groundcommand is through a 3.6 kbps (kilo bytes per second)telemetry link. Total mission cost is about $63 million. After launch, the Lunar Prospector had a 105 cruise to theMoon, followed by insertion into a near-circular 100 kmaltitude lunar polar orbit with a period of 118 minutes. The nominal mission duration is one year. A two yearextended mission following this is possible, during whichthe orbit will be lowered to 50km and then 10km altitude toobtain higher resolution measurements. On March 5th, 1998: On March 5th, 1998, it was announced that data returnedby the Lunar Prospector spacecraft indicated that water iceis present at both north and south lunar poles, in agreementwith Clementine results for the south pole reported inNovember 1996. The ice originally appeared to be mixed inwith the lunar regolith (surface rocks, soil and dust) atlow concentrations conservatively estimated at 0.3 to 1percent. The ice was thought to be spread over 10,000 to50,000 square kilometers of area near the north pole and5,000 to 20,000 square kilometers around the south pole, butthe latest results show the water may be concentrated inlocalized areas rather than being spread out over theselarge regions. The estimated total volume of ice is 6trillion kg. Uncertainties in the models mean this estimatecould be off considerably. How was the ice detected:The Lunar Prospector, a NASADiscovery mission, included a experiment called the NeutronSpectrometer. This experiment is designed to detect minuteamounts of water ice at a level less than 0.01%. Theinstrument concentrated on areas near the lunar poles whereit was thought these water ice deposits might be found. The

Neutron Spectrometer looks for so-called “slow” (or thermal)and “intermediate” (or epithermal neutrons) which resultfrom collisions of normal “fast” neutrons with hydrogenatoms. A significant amount of hydrogen would indicate theexistence of water. The data showed a distinctive 4.6percent signature over the north polar region and a 3.0percent signature over the south, a strong indication thatwater is present in both these areas. How can ice survive on the moon: The moon has no atmosphere, any substance on the lunarsurface is exposed directly to vacuum. For water ice, thismeans it will rapidly sublime directly into water vapor andescape into space, as the Moon’s low gravity cannot hold gasfor any appreciable time. Over the course of a lunar day(29 Earth days), all regions of the moon are exposed tosunlight, and the temperature of the moon in direct sunlightreaches about 395 degrees K (or 250 degrees above F). Soany ice exposed to sunlight for even a short time would belost. The only way for ice to exist on the Moon would be ina permanently shadowed area. The Clementine imaging experiment showed that suchpermanently shadowed areas do exist in the bottom of deepcrater near the Moon’s south pole. In fact, it appears thatapproximately 6000 to 15,000 square km of area around thesouth pole is permanently shadowed. Much of the area aroundthe south pole is within the South Pole-Aitken Basin (shownabove with large arrow pointing to it), a giant impactcrater 2500km in diameter and 12 km deep at its lowestpoint. Any water ice at the bottom of the craters couldprobably exist for billions of years. Where did the ice come from: The Moon’s surface is continuously bombarded bymeteorites and micrometeorites. Many, if not most, of theseimpactors contain water ice, and the lunar craters show thatmany of these were very large objects. Any ice whichsurvived impact would be scattered over the lunar surface. Most would quickly vaporize by sunlight and lost to space,but some would end up inside the permanently shadowedcraters, either by directly entering the crater or migratingover the surface as randomly moving individual moleculeswhich would reach the craters and freeze there. Once insidethe crater, the ice would be relatively stable, so over timethe ice would collect these “cold traps”, and be buried tosome extent by meteoritic gardening. Such a possibility wassuggested as early as 1961 (Watson, 1961). However, loss ofice due to photodissociation, solar wind sputtering, andmicrometeoroid gardening is not well quantified (Arnold,1996).Discussion and Summary:Is there any other evidence for ice? Arecibo regions seem to indicate that water ice is the mostlikely possibility. However, Arecibo radio telescopestudies using the same radio frequency as Clementine showedsimilar reflection patterns from areas which are notpermanently shadowed. These reflections have beeninterpreted as being due to rough surfaces, and it wassuggested that the Clementine results may have been due toroughness, rather than water ice, as well. Why is ice on the Moon important: This ice could represent relatively pristine cometaryor asteroid material which has existed on the Moon formillions or billions of years. A robotic sample returnmission should bring ice back to Earth for study, perhapsfollowed by a human mission for more detailed sampling. Thesimple fact that the ice is there will help scientistconstrain models of impacts on the lunar surface and theeffects of meteorite gardening, photodissociation, and solarwind sputtering on the Moon. Beyond the scientificallyintriguing aspects, deposits of ice on the Moon would havemany practical aspects for future manned lunar exploration. There is no source of water on the Moon, and shipping waterto the Moon for use by humans would be extremely expensive($2,000 to $20,000 per kg). The lunar water could alsoserve as a source of oxygen, another vital material notreadily found on the Moon, and hydrogen, which could be usedas rocket fuel. Paul Spudis, one of the scientist who tookpart in the Clementine study, referred to the lunar icedeposits as possibly “the most valuable piece of real estatein the solar system”. It appears that in addition to thepermanently shadowed areas there are some higher areas suchas crater rims which are permanently exposed to sunlight andcould serve as a source of power for future missions.