行政院所屬各機關因公出國人員出國報告

（出國類別：出席國際會議）

出席「二十一世紀土壤沖蝕研究國際研討會」報告

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摘　要

本次會同本系吳嘉俊教授應邀出席「二十一世紀土壤沖蝕研究研討會」，會中本人以海報張貼開放討論方式發表論文一篇，獲致相當正面評價，使與會的各國相關研究學者及專家，瞭解國內在土壤沖蝕研究上的實力及潛力。

本次研討會的發起，來自於吳教授於 1998 年國際農業工程年會之提議，認為有必要召開一次國際專題研討會，為土壤沖蝕研究邁入二十一世紀規劃出重要的十年方案，同時亦可履行 1995 年美國農業部自然資源保育署（USDA-NRCS）與我國行政院農業委員會（COA）所簽署「中美雙邊水土保持技術交流備忘錄」中的協定。在美國農業工程學會（ASAE）、中華水土保持學會（CSWCS）、行政院農業委員會（COA）及其他共計 11 個國際學術與官方組織的共同支持下，得以順利於 2001 年初於夏威夷召開。

目　　次

一、參加會議目的：

目前學術研究單位在研究土壤沖蝕現象上，其研究的主題大多有越來越細膩的現象。過度精緻的研究課題，已造成研究參數的制定遠離現實；換句話說，目前土壤沖蝕研究已出現試驗室內營造出現實環境中無法實現的虛擬世界。這種現象不僅充斥於土壤沖蝕研究的國際舞台，更是目前台灣在土壤沖蝕研究與土壤流失量估算上所遭遇的問題。

加速研究成果及資源的網路國際化（international networking），是此次與會的心得之一。建議相關部會考慮以研究群的方式，打破校際與研究機關的界線，讓台灣的研究成果早日整合並推向國際舞台。其次，土壤沖蝕的田間試驗（field experiments）及基礎研究資料庫的建立與共享，為本次國際土壤沖蝕研究研討會的重要共識。國內雖有較為優渥的研究資源，但資源的分配往往出現目標或任務導向，缺乏長時間觀測的遠見，使得原先辛苦建立的田間試驗區或長時間積極觀測的重要資料等，流於被迫停擺的命運。在台灣特殊地形、地質與水文條件下所觀測或研究的土壤沖蝕成果，應持續給予經費支援，好讓國內過去及未來的土壤沖蝕研究成果，得以共享甚至貢獻予全世界。

本次出席「二十一世紀土壤沖蝕研究國際研討會」之目的有二：其一為發表研究論文一篇，其二為了解國際在土壤沖蝕方面之研究成果。發表論文共計一篇，題目為「Application of Low Cost Strobe-Photography on Visualization of Droplet Impact」。此次出國參加國際學術研討會，承蒙教育部給予補助，甚感榮幸，核定補助文號：台(89)文(二)八九八九一六七〇七五號。

二、參加會議經過：

- 90.1.2. – 啟程前往美國夏威夷。

- 90.1.3. –「二十一世紀土壤沖蝕研究國際研討會」於上午 8:00 開幕，本次國際會議與會人數達 217 人，分別來自世界十個國家。開幕式中安排三位專家進行專題演講，其演講的重點針對目前風蝕研究與模擬、水蝕研究與模擬及土壤沖蝕量化等三大主題，提出土壤沖蝕研究在二十一世紀中仍需要努力的方向。

本次國際會議由美國農業工程學會（American Society of Agricul-tural Engineers; ASAE）主辦，協辦單位則包括有中華水土保持學會（Chinese Soil & Water Conservation Society; CSWCS, TAIWAN）、行政院農業委員會（Council of Agriculture; COA, TAIWAN）、美國農藝學會（American Society of Agronomy; ASA）、歐洲水土保持學會（European Society of Soil Conservation; ESSC）、國際土壤沖蝕控制協會（International Erosion Control Association; IECA）、國際土壤科學聯盟（International Union of Soil Science; IUSS）、美國土壤科學學會（Soil Science Society of America; SSSA）、水土保持學會（Soil & Water Conservation Society; SWCS）、美國農業部農業研究署（USDA-ARS）、美國農業部合作研究教育推廣署（USDA-CSREES）、美國農業部林業署（USDA-FS）、美國農業部自然資源保育署（USDA-NRCS）及世界水土保持協會（World Association of Soil & Water Conservation; WASWC）。

本次國際土壤沖蝕研究研討會的進行方式，乃是採分組討論分不

同場地同步進行。與會人士可依其興趣與所需，自由穿梭於會場間。分組討論的議題包括：土壤沖蝕機制之試驗研究（Experimental soil erosion process research）、土壤沖蝕控制技術（Erosion control practices）、土壤沖蝕之場內場外衝擊（On-site and off-site impacts of soil erosion）、氣候水文及土壤沖蝕機制之模擬（Modeling of climatic, hydrologic, and soil erosion processes）、土壤沖蝕模式於農業與非農業用地之應用（Applications of soil erosion models to agricultural and non-agricultural lands）、土壤沖蝕研究之量測技術（Measurement techniques in soil erosion research）、水蝕研究（Water erosion research）、風蝕研究（Wind erosion research）及泥砂輸送模擬（Sediment transport modeling）等。

- 90.1.3. – 以海報張貼公開討論方式發表「Application of Low Cost Strobe– Photography on Visualization of Droplet Impact」，獲得相當正面之評價。

- 本次國際會議籌備委員會，為了整合國際土壤沖蝕研究的人力資源，特別安排三個委員討論會，分別為風蝕之機制、模擬與控制（Erosion by wind : processes, modeling and control），水蝕之機制、模擬與控制（Erosion by water : processes, modeling and control）及土壤沖蝕的量化（Quantification of soil erosion by wind and water）。委員討論會的主要目的在檢討目前土壤沖蝕研究及土壤流失量估算模擬技術上的缺失，並提出今後應努力的方向及土壤沖蝕研究在二十一世紀未來十年內的工作重點。

- 90.1.5. – 上午參與委員討論會分組討論之進行。本委員討論會經過 90.1.4.上午集體討論之決議，將中心議題「土壤沖蝕的量化」

分成六個子題，於今天上午利用一個半小時的時間進行分組討論。六個子題包括：(1).國際土壤沖蝕研究網及研究資料庫的建立，(2).成立跨領域研究群對土壤沖蝕複雜機制中數個極具爭議的機制進行深入研究，(3).土壤沖蝕研究監測與量測技術的改進，(4).土壤沖蝕機制之時空變異特性量化，(5).過去國際間所累積土壤沖蝕研究資料之再評估，及(6).土壤沖蝕控制方法對社會經濟層面影響之量化等。

- 90.1.6. – 會議結束，準備返程。
- 90.1.7. – 返回台灣。

三、與會心得：

本次研討會的發起，乃來自於吳教授於 1998 年國際農業工程年會之提議，認為有必要召開一次國際專題研討會，為土壤沖蝕研究邁入二十一世紀規劃出重要的十年方案，同時亦可履行 1995 年美國農業部自然資源保育署（USDA-NRCS）與我國行政院農業委員會（COA）所簽署「中美雙邊水土保持技術交流備忘錄」中的協定。在美國農業工程學會（ASAE）、中華水土保持學會（CSWCS）、行政院農業委員會（COA）及其他共計 11 個國際學術與官方組織的共同支持下，本次國際研討會得以順利於 2001 年初於夏威夷召開。

就土壤沖蝕研究議題而言，本次會議的議題重點放在土壤沖蝕機制之研究，其中包含風蝕之機制、水蝕之機制、風蝕量之估算、水蝕量之估算及沖蝕控制技術等。土壤沖蝕的研究在國際學術研究的舞台上，已歷經相當長的時間，這些研究經驗與知識的累積，帶動了土壤流失量預測模式的發展。再藉由電腦演算能力的進步，使得土壤流失量預測模式，由先前的經驗公式或半經驗公式，進步到現在的模組化

物理機制模式。雖然如此，模組化物理機制模式仍然需要現場實驗的配合，才能夠在電腦協助下，預測土壤的流失量。然而，現場實驗是需要時間的，實驗的成果往往沒有辦法趕上電腦數值模擬的步調，以至於部份電腦數值模擬模式，開始採用外插的方式，將數值模擬的適用範圍強迫推展到現場實驗的範圍之外。大膽外插的結果，往往造成預測的數值過大或過小，甚至完全模擬與現場相違的物理現象。如果姑且不談數值模擬的精確度，數值模擬無限度外插的最大後果，可能造成研究人員對物理現象的誤解，最後以訛傳訛，將研究的方向帶入錯誤的死胡同。

本次土壤沖蝕研究國際研討會各組討論的重點，不外乎對於現行模組式土壤流失量估算模式的精確度與實用性提出質疑；其中又以各模組中所謂的物理機制是否真實描述自然現象，及模組化電腦模式缺乏實用性為主要的討論及爭議焦點。目前學術研究單位在研究土壤沖蝕現象上，其研究的主題大多有越來越細膩的現象。學術研究本應越研究越深入，但土壤沖蝕原屬自然現象，其中所涉及的變數甚多。過度精緻的研究課題，已造成研究參數的制定遠離現實；換句話說，目前土壤沖蝕研究已出現試驗室內營造出現實環境中無法實現的虛擬世界。如此的結果，使得目前土壤流失量估算模式變得過度複雜，所需的基本資料輸入量過細過多，使用者往往落於無基本資料可資使用，而土壤流失量估算的結果卻又不合理的超估。這種現象不僅充斥於土壤沖蝕研究的國際舞台，更是目前台灣在土壤沖蝕研究與土壤流失量估算上所遭遇的問題。

另一個值得國內土壤沖蝕研究群深思的議題，在於跨專業的合作。所謂的跨專業的合作，包含氣象、水文、地質、水利、土壤、農工、農藝、水土保持、輸砂、社會經濟等。本次國際土壤沖蝕研究研

討會已注意到，若要提昇目前土壤沖蝕研究及土壤流失量估算的水準，不能再以單一的農業工程領域為主導，而必須結合水利與輸砂專長的專家，才能較正確地描述地表逕流水的水理及輸砂特性。再者，目前的土壤流失量估算模式大多未考慮不同水土保持處理所造成社會經濟的衝擊，以至於研究所得的水土保持處理往往面臨耗資或所需人力過高而無法推廣的窘境。國內也有類似的狀況，實在值得注意。

加速研究成果及資源的國際網路化（international networking），是此次與會的另一個心得與議題，其目的在減少人力與財力的浪費，更可強化國際間相同研究領域人員的集體合作。因此建議相關部會考慮以研究群的方式，打破國際、校際與研究機關的界線，讓台灣的研究成果早日整合並推向國際舞台。其次，土壤沖蝕的田間試驗（field experiments）及基礎研究資料庫的建立與共享，為本次國際土壤沖蝕研究研討會的重要共識。國內雖有較為優渥的研究資源，但資源的分配往往出現目標或任務導向，缺乏長時間觀測的遠見，使得原先辛苦建立的田間試驗區或長時間積極觀測的重要資料等，流於被迫停擺的命運。在台灣特殊地形、地質與水文條件下所觀測或研究的土壤沖蝕成果，應持續給予經費支援，好讓國內過去及未來的土壤沖蝕研究成果，得以共享甚至貢獻予全世界。

四、建議：

本次應邀參加「二十一世紀土壤沖蝕研究國際研討會」的會後建議條列如下，如有需要進一步瞭解之處，請參考本報告的「三、與會心得」部份。

1. 目前學術研究單位在研究土壤沖蝕現象上，其研究的主題大多有越

來越細膩的現象。過度精緻的研究課題，已造成研究參數的制定遠離現實；換句話說，目前土壤沖蝕研究已出現試驗室內營造出現實環境中無法實現的虛擬世界。這種現象不僅充斥於土壤沖蝕研究的國際舞台，更是目前台灣在土壤沖蝕研究與土壤流失量估算上所遭遇的問題。建議　貴部繼續維持對國內專家學者出席國際會議的補助：尤其是參加自然科學相關的國際會議，除增加我國在國際學術舞台的曝光率與知名度外，更可讓國內專家學者增廣見聞，跟隨甚至領導國際學術研究的腳步。

2. 建議相關部會考慮以研究群的方式，打破國際、校際與研究機關的界線，讓台灣的研究成果早日整合並推向國際舞台。同時，建議　貴部彙同相關部會整合國內各個學術研究群的研究成果，建立網際網路中英文網頁，以便利國內外資料及研究成果的交換，並藉此建立國內研究成果在國際舞台的知名度。

3. 土壤沖蝕的應用及基礎研究，往往較其他學門需要較長的時間方能得到高品質的成果。國內雖有較為優渥的研究資源，但資源的分配往往呈現目標或任務導向，缺乏長時間觀測的遠見，使得原先辛苦建立的田間試驗區或長時間觀測的重要資料，流於被迫停擺的命運。在台灣特殊地形、地質與水文條件下所觀測或研究的土壤沖蝕成果，建議　貴部與相關部會應持續給予經費支援，好讓國內過去及未來的土壤沖蝕研究成果，得以共享甚至貢獻予全世界。

4. 建議　貴部鼓勵受補助出席國際會議的學者專家，於與會期間主動參與、爭取或協助國際學術研討會的舉辦，並於適當時機給於行政或經費上的協助。

Application of Low Cost Strobe–Photography on Visualization of Droplet Impact

Wen-Jaur Chang and Junn-Fu Hsieh [1]

Abstract

Waterdrop impact on soil surfaces is one of the major factors affecting soil erosion. Many researches have utilized high-speed photography to study waterdrop impact and splash. However, the price of high-speed photography equipment was too expensive for a general soil erosion laboratory to afford. In this research a low cost strobe–photography system was developed to satisfy the needs of droplet impact research. The entire system consists of a close-up equipped single lens camera, a set of phototransistors, and a low power laser system. The study was conducted in a dark room. The main function of phototransistors was to trigger a function generator as the incoming laser source being blocked by a waterdrop. A preset delay square wave was sent to excite strobe flashlight to do so that images of waterdrop impact could be clearly registered anytime during the impact process as desired. This system was first applied in the study of droplet impact on water pond surface with different depths of water. Then, the phenomenon of droplet impact on leaf surface was studied as well. The results of these studies showed that it was possible to calculate the shear stress during droplet impact from sequential pictures taken with this technique. Also, the pictures of droplet impact on leaf surface revealed that most of droplet mass was splashed into air immediately after impact then transformed into smaller droplets and fell outside the leaf edge. This result suggested that kinetic energy of droplets dripping from leaf surface might have been overestimated in the past. These results enhance the possibility of low cost droplet visualization as well as better understanding in qualitative correlation between droplet impact and soil erosion.

Keywords. Soil erosion, Waterdrop impact, Strobe-photography.

Introduction

Waterdrop impact on soil surface, causing soil aggregate detachment, is one of the major factors affecting soil erosion. In general, direct measurement (Nearing et al. 1986), computer simulation (Chang and Hills. 1993) and high–speed photography (Ghadiri and payne. 1986) are the three categories of methods that have been successfully applied an watersrop impact researches. In this research the images of waterdrop impact and splash were emphasized. Duration of watersrop impact is very short. It is impossible to observe the progress of waterdrop impact by bare eyes. High–speed photography equipment with photographic rate above 1,000 frames per second have been used widely by researcher to study waterdrop impact and splash (Mutchler, 1967; Ghadiri and Payne, 1981,1986; Fukada and Fujiwara, 1989.) However, the price of high-speed photography equipment was too expensive for a general soil erosion laboratory to afford, hence a low cost strobe-photography system was developed to emulate quasi-high-speed photography.

Strobe-photography System

Concepts and Hardware

Pictures of waterdrop impact were taken in a dark room with close-up equipped single lens camera(Nikon F4). The instant of exposure was controlled by stroboscope. In order to freeze the image of waterdrop impact at any instant during the impact process as desired. A low power, red light laser beam and a set of accompanied phototransistors were set at position of 35cm above impact surface to detect the moment when waterdrop falling through this certain location. As soon as phototransistors sensing the falling waterdrop to block laser beam. The circuit latched this signal and triggered a function generator (Hp 33120A). Then a preset delay square wave was sent out from function generator to excite stroboscopes. In this research 6 stroboscopes were

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used and divided evenly into two groups. The preset delay square wave was composed by delay part and duty cycle. The delay part of square wave kept at low level voltage to provide sufficient delay time for waterdrop falling close to impact surface. Rising edge of square wave then excited the first group of stroboscopes to freeze the image of waterdrop close to impact surface. Following after duty cycle the falling edge of square wave excited the second group of stroboscopes to freeze he image of waterdrop splash at impact surface. Each frame of film was a double exposure. Refering to the waterdrop position of the first image and duty cycle of square wave the occurrence instant of second image could be estimated more accurately. By adjusting duty cycle of preset square wave in each picture shooting, the image of waterdrop impact and splash at any instant during the impact process could be collected (plate 1).

Measurement

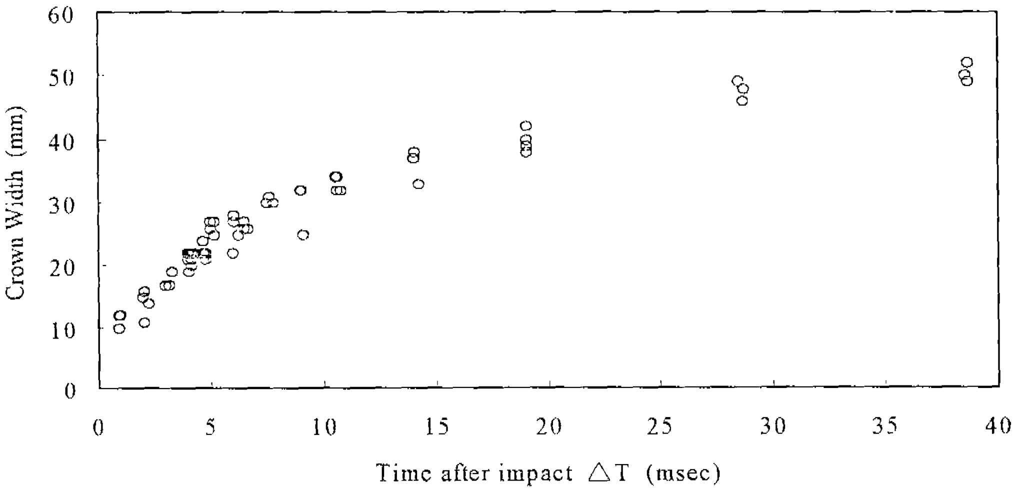
Slide film was used in this research to take waterdrop impact pictures. The pictures then projected on to a screen for measurement. The scale ruler that had been used in splash parameter measurement was a picture of straight ruler that kept the same magnified scale as the impact pictures. Fig. 1 showed the evolution of splash crown width and height of waterdrop impact on water pond. Based on the principle of momentum equation, it is possible to calculated vertical impact force and shear stress from Fig. 1 with reasonable assumptions. Other than pictures of waterdrop impact on water pond, pictures of waterdrop impact on leaf surface were taken with same technique also. Qualitative observation on these pictures showed that most of droplet mass was splashed into air immediately after impact then transformed into smaller droplets and fell outside the leaf edge. This result suggested that kinetic energy of droplets dripping from leaf surface might have been overestimated in the past.

Limitations and Advantages

Unlike high-speed photography that take sequent pictures during impact progress of a single waterdrop, this quasi-high-speed photography or strobe-photography only take one picture at a certain instant during impact progress of a single waterdrop. With different setting on duty cycle of delay square wave might help to take sequent pictures of waterdrop impact progress (plate 1). But each waterdrop has slightly different characters than other waterdrop, even if they all dripped from same waterdrop generator. So, scattered data point in Fig. 1 is unavoidable. The major advantages of this strobe-photography were low cost and convenience. All hardware applied in this photography was rather common equipment in general laboratory. Comparing with a professional high-speed photography, the purchase cost of this photography system was relatively low. Besides, the operation fee of this system was only limited to general photo picture development fee. Therefore, the photographic technique developed in this paper was a rather economical and convenient strobe-photography for studying the correlation between waterdrop impact and soil erosion.

Summary

Photography that preserved images of waterdrop impact progress was the most direct method revealing the parameters that related to soil erosion. Relating research papers have shown that high-speed photography equipment were applied extensively to waterdrop impact and splash study by researchers. However, the price of high-speed photographic equipment together with operation fee might be too high for a general soil erosion laboratory to afford. In this paper a general photo camera was used with the dark room photography. A phototransistor was utilized as a laser beam sensor to detect the moment when the waterdrop passing through certain location. After then latch circuit actuated function generator to send out a preset delay signal which might excite flash light for taking pictures of waterdrop splash. The technique was mature enough for taking high quality pictures of waterdrop splash at any impact instant. Pictures taken with this technique might provide sufficient information for soil erosion research.



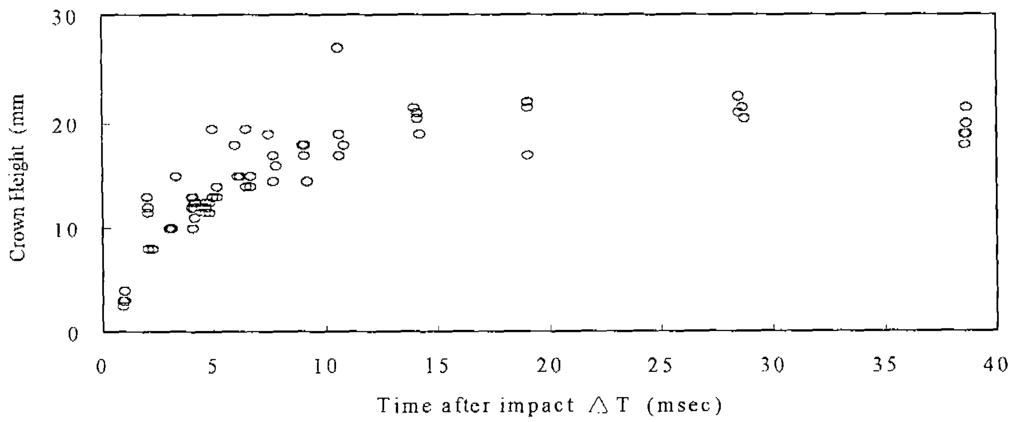


Fig.1 Evolution of splash crown width and height for a 6mm waterdrop impact on a 7mm depth water pond with impact velocity of 6m/sec.

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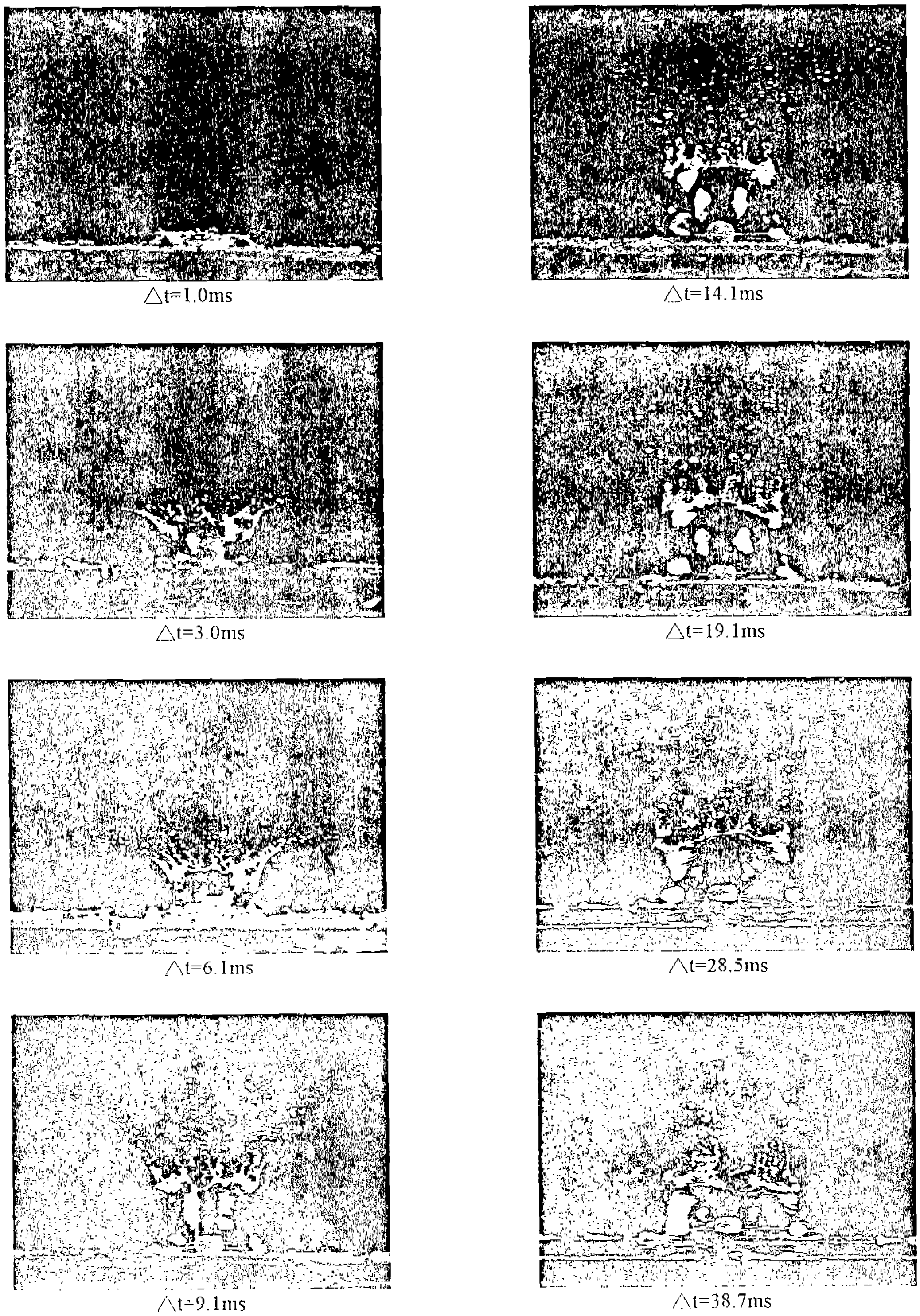

Plate 1 Sequent pictures of a 6mm waterdrop impact on a 7mm depth pond with impact velocity of 6m/sec.