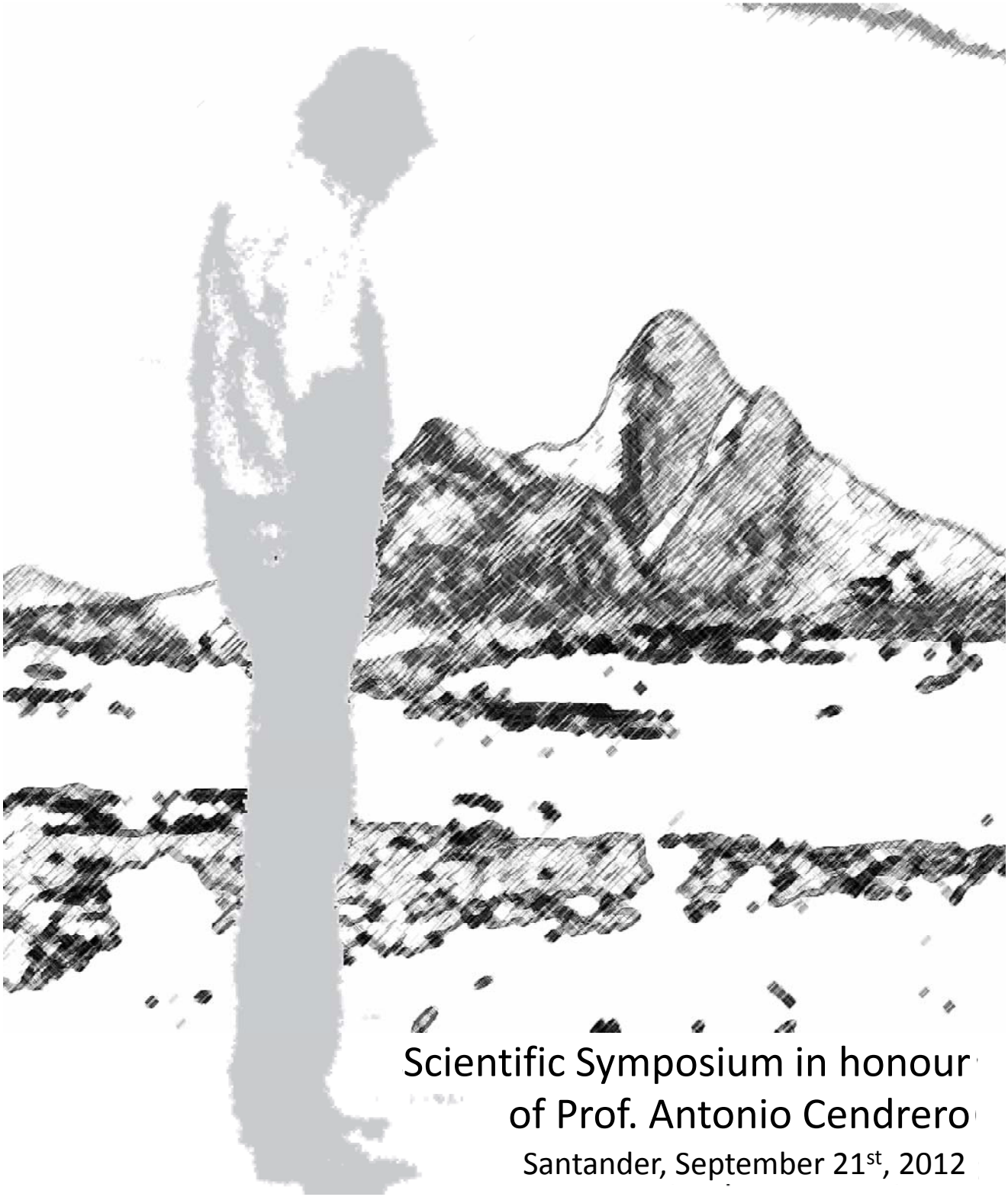
FROM ENVIRONMENTAL GEOLOGY TO GLOBAL GEOMORPHIC CHANGE



Scientific Symposium in honour of Prof. Antonio Cendrero

Santander, September 21st, 2012

Editors: Juan Remondo, Jaime Bonachea, Viola Bruschi

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Scientific Simposyum in honour of Prof. Antonio Cendrero

Santander, September 21, 2012

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INTRODUCTION

The purpose of this International Symposium is to pay tribute to the research and educational activity carried out by the Prof. Antonio Cendrero Uceda.

The Symposium's name reflects his professional career since the seventies, focused on the study of the interactions between man and the geological environment, commonly termed environmental geology. A. Cendrero has had a fruitful and pioneering career of research and dissemination in the discipline. During recent years his research has concentrated on the study of impacts of human actions on geomorphologic processes and risks, within the context of global change. Always from a geological and geomorphological point of view, he has dealt with natural risks, interactions between human activity and geomorphic processes, geoenvironmental analysis and assessment in the sustainable management of geologic resources and land use planning, etc.

The one day symposium will be held following the *XII Reunión Nacional de Geomorfología* (XII National Meeting on Geomorphology), facilitating synergy between both events. The Symposium offers an excellent framework for scientific dissemination and discussion on the subject, by means of oral and/or poster presentations on current research.

ANTONIO CENDRERO UCEDA: UNA LARGA Y FRUCTÍFERA TRAYECTORIA ACADÉMICA Y CIENTÍFICA

José Ramón Díaz de Terán Mira (DCITIMAC. Universidad de Cantabria)

La ciencia del hombre es la medida de su potencia, porque ignorar la causa es no poder producir el efecto. No se triunfa de la naturaleza sino obedeciéndola, y lo que en la especulación lleva el nombre de causa conviértese en regla en la práctica.
(Aforismo 3 del Libro Primero, "Aforismos sobre la Interpretación de la Naturaleza y el Reino del Hombre", de la obra Novum Organum, 1620, de Francis Bacon)

Antonio Cendrero Uceda nació en Madrid el año 1941. Pertenece a una familia de ilustres naturalistas, como su abuelo Orestes Cendrero Curiel (Doctor en Ciencias Naturales, pensionado por la Junta de Ampliación de Estudios y Catedrático del entonces Instituto Nacional de Segunda Enseñanza de Santander, así como autor de varios libros de texto que se han editado en diversos países), su mismo padre Orestes Cendrero Curiel (hijo de Orestes Cendrero Curiel y de María Curiel), también Licenciado en Ciencias Naturales y Profesor del Instituto de Segunda Enseñanza Santa Clara de Santander. Su hermano, Orestes Cendrero Uceda, es un reconocido especialista en Biología Marina y fue director del centro del Instituto Español de Oceanografía en Santander.

Se licenció en Ciencias Geológicas en la Universidad Complutense de Madrid en 1965 con Premio Extraordinario; en 1970 presentó su Tesis Doctoral en la Universidad Complutense de Madrid, siendo dirigida por el Profesor José María Fúster Casas, y obteniendo también Premio Extraordinario. El tema de su tesis fue el estudio geológico y petrológico de las rocas plutónicas del complejo basal de la isla de La Gomera en el Archipiélago Canario (Cendrero, 1971a). Su curriculum académico le ha hecho merecedor de algunas de las becas más importantes españolas y extranjeras (Beca de la Fundación Juan March para estudios en España, 1967; Beca del Dartmouth College (USA) para estudios de post-grado, 1967-68; Complemento de beca del Patronato Alonso de Herrera, CSIC, para estudios en USA, 1967-68; Beca del Programa de Formación de Personal Investigador, 1969-70; Beca Fulbright-Hays para trabajo post-doctoral en USA, 1974)

Desde el mismo año (1965) en el que concluyó su licenciatura y hasta el año 1967, desempeñó funciones docentes como Profesor Ayudante en la Universidad Complutense de Madrid, mientras que durante este mismo periodo, como Contratado de Nivel Superior, estuvo realizando tareas de investigación en el CSIC. Desde 1967 a 1968, realizó una estancia predoctoral, en funciones de Teaching Assistant, en el Dartmouth College (USA). A su regreso a España en 1968 y hasta 1970, reanuda sus tareas docentes en la Universidad Complutense, como Profesor Encargado, y como investigador en el CSIC (Contratado, Nivel Superior). De 1970 a 1971 se desempeña como Lecturer en la Universidad de Sulaimaniyah (Irak). En 1971 obtiene por oposición la plaza de Profesor Agregado en la Universidad de Cantabria y en 1977 la de Catedrático, en la misma Universidad.

Ha realizado numerosas estancias de trabajo en diversas universidades e instituciones de investigación extranjeras. Las ya citadas en el Dartmouth College (1967-1968) y en la Universidad de Sulaimaniyah (1970-1971), así como otras posteriores en universidades americanas y europeas. Algunas de estas estancias han tenido una gran importancia en el devenir de su actividad académica y científica, en la cual se pueden establecer tres etapas principales en función de la evolución de sus intereses e inquietudes profesionales. A este respecto, se puede establecer una primera época dedicada a la petrología y volcanología,

marcada por su relación con el profesor Fúster y la realización de su tesis doctoral (1965-1974). Una segunda época para la que fue determinante su estancia, durante 1974, en el Bureau of Economic Geology de la Universidad de Texas en Austin (USA) y donde entró en contacto con el nuevo y amplio campo de la Geología Ambiental, realizando a su vuelta a España una fecunda y pionera labor de investigación y difusión de esta disciplina en nuestro país, destacando como hitos principales la fundación de la Sociedad Española de Geología Ambiental y Ordenación del Territorio, de la que fue primer presidente, así como del Comité Organizador de la I Reunión Nacional de Geología Ambiental y Ordenación del Territorio, celebrada en Santander, en 1980. Asimismo, tuvo una destacada participación en el desarrollo de esta disciplina en Europa junto a notables científicos como Lüttig, Wolff y De Mulder; consecuencia de esta actividad fue la creación en 1990 de la Comisión sobre Geología Ambiental y Planificación Ambiental de la International Union of Geological Sciences (COGEOENVIRONMENT) de la que fue el primer Vicepresidente.

En lógica continuidad con esta vertiente ambiental de la Geología, aparecen con posterioridad sus inquietudes acerca de los nuevos campos que se ofrecen al investigador sobre los riesgos naturales y sus relaciones con la problemática derivada del Cambio Global, así como la influencia del hombre sobre la magnitud de estos cambios y en los procesos geológicos con ellos conectados. Sus estancias de larga duración en la California State University (Long Beach, USA) durante 1994-95, en la Universidad Autónoma de Baja California (Ensenada, México) durante parte de 1994 y, por último, en la Universidad Nacional de La Plata (La Plata, Argentina) durante 2001-2002, jalonan esta tercera etapa de su larga trayectoria académica e investigadora.

Durante los 41 años (1971-2012) en los que Antonio Cendrero ha desarrollado su labor docente e investigadora en la Universidad de Cantabria, ha dirigido un total de 10 tesis doctorales (Díaz de Terán, 1985; Alonso Herrero, 1987; Francés, 1987; Rivas, 1991; Salas, 1993; González-Díez, 1995; Remondo, 2001; Weischelgartner, 2002; Bruschi, 2007; Dantas-Ferreira, 2008). Su actividad como docente en el Departamento de Ciencias de la Tierra y Física de la Materia Condensada (DCITIMAC) de la Universidad de Cantabria se ha centrado fundamentalmente en asignaturas sobre Geología General, Geofísica, Geología Ambiental y Riesgos Geológicos. Ha impartido también gran número de cursos de postgrado en la propia Universidad de Cantabria, así como en diversas universidades europeas y americanas (Salta, La Plata, Tucumán, Mar del Plata, Rio Cuarto, Rio de Janeiro, Ensenada (Baja California), Lima y Praga). Igualmente su presencia como conferenciante invitado ha sido frecuente en distintos ámbitos académicos e instituciones (Ensenada (México), Bogotá, Medellín y Pereira (Colombia), Buenos Aires, Salta, Tandil y Rio Cuarto (Argentina), Rio de Janeiro y Goiás (Brasil); Montevideo (Uruguay), Lima (Perú), Guayaquil (Ecuador), Managua y León (Nicaragua), San José (Costa Rica), Allahabad (India), Pekin (China), Amsterdam, Delft y Enschede (Holanda), Berlín (Alemania), Lisboa, (Portugal), Nantes y Granville (Francia), Florencia y Cortina D'Ampezzo (Italia), Long Beach (USA), Viena y Dornbirn (Austria), Praga (República Checa), Mamaia (Rumanía), Lomé (Togo), Addis Abeba (Etiopía)).

En el año 2000 fue elegido Académico Numerario de la Real Academia Española de Ciencias Exactas, Físicas y Naturales. Pertenece además a algunas de las más importantes sociedades científicas españolas y extranjeras (International Association of Geomorphologists, American Association for the Advancement of Science, Mineralogical Society of America, Geological Society of America, British Quaternary Research Group, Societé Géologique de France, Indian Association of Geomorphologists (miembro honorario), Sub-Commission on Maps of Environmental Geology (CGMW-IUGS), Sub-Comission on Applied Quaternary Research (INQUA), European Union of Geosciences, Real Sociedad Española de Historia Natural, Sociedad Geológica de España, Sociedad Española de Geomorfología, Asociación Española para el Estudio del Cuaternario, Sociedad Española de Geología Ambiental y Ordenación del

Territorio).

A lo largo de su dilatada vida académica ha pertenecido a muy diversos organismos y comisiones científicas tanto nacionales como extranjeras (Vice-presidente, Commission on Earth Sciences for Environmental Planning and Management, International Union of Geological Sciences, 1990-94; Comité Ejecutivo. Centre Européen pour les Risques Géomorphologiques. Consejo de Europa, Estrasburgo, 1990-93; Comité Científico. Centro Internazionale di Studi Giuridici e Politici sull'Ambiente. Florencia, 1990-92; Representante de la IUGS ("International Union of Geological Sciences") y de la UIP (Universidad Iberoamericana de Postgrado) en la Conferencia de Naciones Unidas sobre Medio Ambiente y Desarrollo, Rio de Janeiro, 1992; Vice-Presidente. Centre d'Activités de Recherche Multidisciplinaire et d'Etudes sur le Littoral. EUROCOAST, La Seyne sur Mer, 1993-98; Commission on Engineering and Environmental Geological Maps. International Association of Engineering Geology, 1992; Commission on Applied Quaternary Research, INQUA, 1992-97; Working Group on Environmental Geoindicators, IUGS, 1992-96; Comité de expertos del Programa ALFA (Comisión Europea) para la adaptación de curricula universitarios de Ciencias e Ingeniería en América Latina y Europa, 1994-97; Experto para la evaluación de proyectos del programa Environment, (cambios climáticos y riesgos naturales) y ENRICH, Comisión Europea, 1993, 94, 97, 98; Representante oficial de la International Union of Geological Sciences ante la Asamblea General de SCOPE (Scientific Committee on Problems of the Environment, International Council of Scientific Unions), 1996-98; Miembro del "Steering Committee" de GTOS (Global Terrestrial Observation System, FAO, ICSU, UNEP, UNESCO, WMO), 1996-98; Miembro del Advisory Committee, Centre of Excellence for Research on the Abiotic Environment, Instituto Geológico de Polonia; Miembro del Comité Científico Asesor del Ministerio de Medio Ambiente de España.

Su producción científica es inmensa, como corresponde a tan larga y fructífera carrera académica, a lo largo de la cual ha participado como investigador principal o coprincipal en 35 proyectos, muchos de los cuales se han plasmado en más de 260 publicaciones científicas nacionales e internacionales, algunas de ellas constituyen importantes hitos por la nueva temática tratada, o por plantear nuevos problemas, incluso aportando ideas y métodos para abordarlos desde una perspectiva novedosa. Sus principales líneas de investigación han estado centradas en los siguientes temas: Geología de regiones volcánicas; Análisis, evaluación, planificación y gestión ambiental integrados; Cartografía geoambiental; Análisis y evaluación de riesgos naturales (especialmente geomorfológicos y litorales); Interacciones entre actividades humanas y procesos terrestres superficiales; Procesos geomorfológicos y cambio global; Indicadores e índices ambientales para el diagnóstico de la calidad ambiental y la sostenibilidad.

Sus comienzos en el trabajo de investigación, y lógicamente su producción científica inicial, tienen que ver con los primeros trabajos suyos relacionados con la petrología y la vulcanología, que abarcan desde 1966 a 1972 y entre los que destaca su participación como coautor en la realización de 12 hojas del Mapa Geológico de España a escala 1:50.000, correspondientes a diferentes islas canarias (Fúster, Cendrero, Sagredo y Sánchez, 1967**;** Fúster, Cendrero y Sagredo, 1967a; Fúster y Cendrero y Sagredo, 1967b; Fúster y Cendrero, 1967; Fúster, Cendrero, Hernández-Pacheco, Páez y Sagredo, 1967; Fúster, Aguilar, Agostini, Bravo, Castañón, Cendrero, Coello, Sánchez y López, 1967; Fúster, Aguilar, Cendrero, Hernández-Pacheco y López, 1967; Fúster, Agostini, Aguilar, Bravo, Castañón, Cendrero, Hernández-Pacheco y López, 1967; Fúster, Alonso, Cendrero, Gastesi, Hernández-Pacheco, Muñoz, Sánchez, Agostini, Aguilar, Bravo y López, 1967; Fúster, Cendrero y Sagredo, 1967; Fúster, Cendrero, Gastesi, Araña, Navarro, Bravo y Coello, 1968; Fúster, Alonso, Araña, Cendrero y Navarro, 1968). Asimismo, son reseñables sus trabajos sobre el complejo volcano-plutónico de La Gomera (Cendrero, 1970), sobre la geología y

volcanología de las Islas Canarias (Fúster, Cendrero, Gastesi, Ibarrola y López, 1968) y sus publicaciones sobre la geología del Kurdistán iraquí (Cendrero, 1971a; Cendrero, 1971a). Aunque cronológicamente separados de esta primera etapa, pero temáticamente afínes son las publicaciones sobre la génesis y cronología de las erupciones canarias (Cantagrel, Cendrero, Fúster, Ibarrola, and Jamond, 1984; Ancochea, Cendrero, Fúster, Ibarrola, Coello, Hernán, Cantagrel y Jamond, 1989; Ibarrola, Ancochea, Casquet, Fúster, Hernán, Cendrero, Díaz de Terán, Cantagrel, Jamond, 1989; Casquet, Ibarrola, Fuster, Ancochea, Cantagrel, Jamond, Cendrero, Díaz de Terán, Hernán, 1989**;** Ancochea, Fuster, Ibarrola, Coello, Hernán, Cantagrel, Jamond, Cendrero, 1989**;** Fúster, Ancochea, Ibarrola, Coello, Hernán, Cantagrel, Jamond, Cendrero, 1989**;** Ancochea, Fuster, Ibarrola, Cendrero, Coello, Hernán, Cantagrel and Jamond, 1990; Coello, Cantagrel, Hernán, Fúster, Ibarrola, Ancochea, Casquet, Jamond, Díaz de Terán and Cendrero, 1992; Ancochea, Hernán, Cendrero, Cantagrel, Fúster, Ibarrola and Coello, 1994), así como sobre las relaciones entre la dinámica eruptiva y los procesos superficiales derivados de la misma (Thouret, Cendrero, Janda, Pierson et Calvache, 1987).

Su fundamental aportación a la Geología Ambiental en España, y a la problemática ambiental en general, se inicia con dos publicaciones (Cendrero, 1975a, c), la primera en la prestigiosa revista *Environmental Geology*, mientras que la segunda recoge su Lección Inaugural del Curso 1975-1976 en la entonces Universidad de Santander. Estas dos primeras publicaciones se complementan con otra aparecida un poco más tarde en el volumen de Ponencias de la I Reunión Nacional de Geología Ambiental y Ordenación del Territorio (Cendrero, 1980a) y en la que se establecen las bases doctrinales y metodológicas de la Geología Ambiental. Mientras aparecen dos artículos en la revista *Landscape Planning*, en uno de los cuales se presentan las bases de lo que después se conocería como el Sistema de la Universidad de Cantabria para la Cartografía Geocientífica (Cendrero, Saiz and Díaz de Terán, 1976), mientras que en el otro (Cendrero, Antón and Saiz, 1977) se aborda un problema de conservación de taludes en una nueva autopista. Los numerosos trabajos relacionados con la planificación y ordenación territorial quedan reflejados en varios artículos en muy diversas publicaciones (Escribano, Cendrero et al., 1978; Cendrero, A. Ramos y C. Steinitz (eds.), 1979; Cendrero, 1980b; Cendrero, et al., 1980; Cendrero et al., 1982; Cendrero, 1982a; Cendrero, 1982b; Cendrero, 1982c; Cendrero y Trilla, 1983; Cendrero, Díaz de Terán y González Lastra, 1984; Águeda, Cendrero et al., 1984; Cendrero et al., 1986; Cendrero and Díaz de Terán, 1987; Cendrero, Elízaga y Gallego, 1987; Cendrero, 1989a; Cendrero, 1989b; Cendrero, 1989c; Cendrero, ed., 1989; Francés, Cendrero et al., 1990; Francés, Díaz de Terán, Cendrero, et al., 1990; Francés, Gómez-Orea, Cendrero et al., 1990; Francés, Díaz de Terán, Cendrero, Gómez-Orea, Vilariño, 1990; Cendrero, 1991; Cendrero, Díaz de Terán, Francés, 1994; Fischer, Rivas and Cendrero, 1995; Cendrero, 1995; González-Díez, Cendrero et al., 2000).

Como no podía ser menos, una importantísma faceta de la actividad académica de Antonio Cendrero es la relacionada con la enseñanza y la didáctica de la Geología y del Medio Natural en los distintos niveles de la educación, así como su divulgación entre el gran público. Su etapa como director del Instituto de Ciencias de la Educación de la entonces Universidad de Santander (1973-1978) supuso la introducción, en los distintos niveles de la enseñanza en Cantabria, de los métodos y técnicas docentes más actuales y avanzados, entre otros la programación de las materias por objetivos (Cendrero, Caloca y Ramos, 1979; Cendrero, 1980; Agudo, Cendrero et al., 1980c; Agudo, Cendrero et al., 1980d; Antón, Cendrero, Díaz de Terán y González, 1982; Cendrero, Díaz de Terán, Flor y González, 1982; Cendrero y González, 1983; Cendrero, Díaz de Terán, González y Flor, 1983; Cendrero, Díaz de Terán, Francés, González y Loriente, 1983; Cendrero, Francés, Manso y Martín, 1984; Cendrero, Díaz de Terán y Fernández, 1984; Cendrero, 1985; Moreno y Cendrero, 1987;

Cendrero, 1989; Cendrero, 1992; Cendrero et al., 1993; Barba, Díaz de Terán, Salas, Cendrero y Valdeolivas, 1996).

Las cuestiones relativas a la inventariación, valoración y gestión del patrimonio geológico también ha sido objeto preferente y constante de su atención, pudiéndose decir en este sentido que su labor, pionera en nuestro país, fue también determinante para que el Instituto Geológico y Minero de España (IGME) emprendiera la tarea de inventariación y catalogación de los Puntos de Interés Geológico de España y precisamente comenzando por el Sector Oriental de la Cordillera Cantábrica (IGME, 1983, Puntos de Interés Geológico en el Sector Oriental de la Cordillera Cantábrica). Muchos de los trabajos de recopilación realizados previamente en el Departamento sirvieron para seleccionar los Puntos de Interés más relevantes de la Cordillera Cantábrica y elaborar toda una serie de publicaciones y mapas de divulgación, metodologías de estudio del patrimonio, incluso una tesis doctoral (Cendrero, Díaz de Terán, Flor y González, 1982; Cendrero y González, 1983; Cendrero, Díaz de Terán, González y Flor, 1983; Cendrero, Díaz de Terán, Francés, González y Loriente, 1983; Cendrero, Francés, Manso y Martín, 1984; Cendrero, Díaz de Terán y Fernández, 1984; Cendrero et al., 1986; Moreno y Cendrero, 1987; Cendrero, Díaz de Terán y Francés, 1991; Cendrero et al., 1993; García, Gallego, Palacio, Cendrero, Elízaga, Cabra, 1993; Cendrero, 1996a; Cendrero, 1996b; Cendrero, 2000; Bruschi, Cendrero, Cuesta-Albertos, 2011; Bruschi, 2007).

A finales de los ochenta y principios de los noventa del pasado siglo despiertan su interés diversos aspectos relacionados con el Cuaternario y la Geomorfología y más concretamente con procesos superficiales como los ligados a la evolución de laderas, a la dinámica costera, etc. (Moñino, Cendrero y Díaz de Terán, 1987; Rivas y Cendrero, 1987; Moñino, Díaz de Terán y Cendrero, 1988; Cendrero, Díaz de Terán y Otamendi, 1988; Moñino, Cendrero y Díaz de Terán, 1988; Moñino, Ortega, Cendrero y Díaz de Terán, 1988; Cendrero, Díaz de Terán, Moñino, 1988; Salas y Cendrero, 1989; Rivas y Cendrero, 1990; Rivas y Cendrero, 1991; González, Díaz de Terán and Cendrero, 1992; Rivas y Cendrero, 1992a; Rivas and Cendrero, 1992b; Cendrero, et al., 1994; González, Salas, Cendrero, Remondo y Díaz de Terán, 1996; González, Salas, Díaz de Terán and Cendrero1996; Cendrero and Dramis, 1996; Soto, Gómez, Ródenas y Cendrero, 1997; González, Remondo, Díaz de Terán and Cendrero, 1999; Soto, Gómez, Cendrero et al., 2000; Gutiérrez, Galve, Guerrero, Lucha, Cendrero et al., 2007).

También desde muy temprano dedica atención al análisis de los riesgos naturales desde la doble perspectiva de su evaluación y modelización (Cendrero et al., 1987a; Cendrero et al., 1987b; Cendrero et al., 1987c; Díaz de Terán y Cendrero, eds., 1992; Cendrero, 1992; Cendrero, 1994; Cendrero, 1995; Remondo, Díaz de Terán, Cendrero et al., 1996; Cendrero, 1997; Díaz de Terán, Cendrero et al., 1997; Remondo, González, Díaz de Terán, Cendrero, Fabbri, Chung, 2003; Remondo, González, Díaz de Terán, Cendrero, 2003; Fabbri, Chung, Cendrero, Remondo, 2003; Remondo, Bonachea, Cendrero, 2004; Bonachea, Remondo, Cendrero, 2004; Remondo, Bonachea, Cendrero, 2005; Remondo, Bonachea, Cendrero, 2008; Galve, Bonachea, Remondo, Gutiérrez, Lucha, Cendrero, Gutiérrez and Sánchez, 2008; Bonachea, Remondo, González, Díaz de Terán, Cendrero, 2009; Galve, Gutiérrez, Lucha, Bonachea, Remondo, Cendrero, Gutiérrez, Gimeno, Pardo, Sánchez, 2009; Galve, Gutiérrez, Cendrero, Remondo, Bonachea, Guerrero, Lucha, 2009; Bonachea, Remondo, Díaz de Terán, González, Cendrero, 2009; Galve, Gutiérrez, Lucha, Guerrero, Remondo, Bonachea, Cendrero, 2009; Galve, Gutiérrez, Bonachea, Lucha, Remondo, Cendrero, Gutiérrez, Gimeno, Pardo, Sánchez, 2009).

La evaluación ambiental del territorio, de cara a la planificación del mismo, o a la estimación de posibles impactos, así como la utilización de índices e indicadores para evaluar la sostenibilidad de determinadas áreas, han sido temas de estudio tanto en relación con la

investigación de métodos como en la aplicación de éstos a zonas concretas (Cendrero, 1989; Francés, Cendrero, Morey, 1989; Cendrero and Charlier, 1989; Alonso, Francés and Cendrero, 1990; Francés, Díaz de Terán y Cendrero, 1990; Díaz de Terán, Francés, Duque and Cendrero, 1992; Cendrero, 1994; Rivas, González, Fischer and Cendrero, 1994; Rivas, Fischer and Cendrero, 1994; Rivas and Cendrero, 1995; González, Díaz de Terán, Francés and Cendrero, 1995; Rivas, Rix, Francés, Cendrero and Brunsden, 1995; Fabbri and Cendrero, 1995; Rivas, Rix, Francés, Cendrero and Brusden, 1997; Cendrero, 1997; Cendrero and Fischer, 1997; Cendrero and Panizza, 1999; Cendrero, 2000; Bertens, Tamés, Cendrero and van Asch, 2000; Cendrero, Marchetti, Panizza and Rivas, 2001; Cendrero et al., 2002; Cendrero et al, 2003; Cecioni, Pineda, Cendrero, Hurtado, Panizza, 2004; Otero, Bruschi, Cendrero, Iglesias, Lázaro, Togores, 2004; Bonachea, Cendrero et al., 2005; Cendrero et al., 2005).

El Cambio Global, la influencia del hombre sobre la magnitud de los cambios y sobre los procesos geomorfológicos con ellos relacionados, captan en los últimos años su atención hasta el punto que su discurso de ingreso en la Real Academia de Ciencias Exactas, Físicas y Naturales tuvo el siguiente sugerente título: “De la Comprensión de la Historia de la Tierra al Análisis y Predicción de las Interacciones Entre Seres Humanos y Medio Natural” (Cendrero, 2003); puede decirse que su bibliografía sobre la temática es amplia (Rivas y Cendrero, 1996; Cendrero, 1997; Cendrero, 2000; Rivas, Remondo, González y Cendrero, 2002; Cendrero and Remondo, 2002; Remondo, González, Soto, Díaz de Terán, and Cendrero, 2005; Cendrero, Rivas, Remondo, 2005; Rivas, Cendrero et al., 2006; Cendrero et al., 2006; Cendrero, Remondo, Bonachea, Rivas, 2006; Cendrero et al., 2007; Cendrero, Bonachea, Remondo, 2009; Cendrero et al., 2010).

Otros muchos temas quedan reflejados en su producción bibliográfica. Por ejemplo, los procesos de relleno antrópico de los estuarios del Cantábrico y sus consecuencias ambientales (Cendrero y Díaz de Terán, 1977; Cendrero, Díaz de Terán and Salinas, 1981; Rivas y Cendrero, 1992; Rivas y Cendrero, 1993), el deterioro de las pinturas de la Cueva de Altamira en relación con la geología de la cueva (Valle, Moya y Cendrero, 1978; Valle, Moya y Cendrero, 1979), la prospección de yacimientos arqueológicos mediante técnicas geofísicas (Cendrero y Martínez, 1985), el glaciarismo en la Cordillera Cantábrica (Moñino, Díaz de Terán y Cendrero, 1988; Moñino, Cendrero y Díaz de Terán, 1988), incluso una obra, “Guía de la Naturaleza de Cantabria” (Cendrero et al., 1986) que conoció tres ediciones y que ahora sólo es posible encontrar en librerías de viejo.

Por último, este relato quedaría incompleto si se dejara de mencionar dos relevantes méritos de Antonio Cendrero que tienen que ver con su vertiente más humana y personal. Uno de ellos se refiere a su reconocida capacidad como organizador y anfitrión de los “seminarios” de fin de semana sobre el juego del mus, que vienen celebrándose de manera ininterrumpida desde hace varios años en su casa y que congregan en torno a la mesa de juego a un selecto grupo de expertos en la materia, convocados todos ellos personalmente por el profesor Cendrero (por parte de algunos discípulos, interesados en participar en tales cenáculos, se espera con impaciencia la publicación de las “actas” de tan trascendentales reuniones). El otro, tiene que ver con sus prácticas sobre la “jardinería sostenible”, actividad que desde sus inicios hace varias décadas viene desarrollando con notable éxito en el bosquete que circunda su casa, lo que se ha traducido en el mantenimiento de la vegetación autóctona del mismo (incluso de la fauna asociada) y que además le suministra el combustible necesario para la chimenea de la sala de estar de su vivienda (Antonio Cendrero, comunicación personal).

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ANTONIO CENDRERO: A LONG AND FRUITFUL ACADEMIC AND SCIENTIFIC CAREER

José Ramón Díaz de Terán Mira (DCITIMAC. University of Cantabria)

Human knowledge and human power meet in one; for where the cause is not known the effect cannot be produced. Nature to be commanded must be obeyed; and that which in contemplation is as the cause is in operation as the rule.
Aphorism III. Book I, "*Aphorisms Concerning the Interpretation of Nature, and the Kingdom of Man*", Novum Organum (1620) Francis Bacon

Antonio Cendrero Uceda was born in Madrid in 1941. He comes from a family of distinguished naturalists, such as his grandfather Orestes Cendrero Curiel (Doctor of Natural Sciences, previously of the Board of Advanced Studies and professor of the then National Institute of Secondary Education, Santander, as well as author of various text books published in many countries), or his father Orestes Cendrero Curiel (son of de Orestes Cendrero Curiel and María Curiel), also a Bachelor of Natural Sciences and teacher at the Santa Clara Secondary School, Santander. Antonio's brother, Orestes Cendrero Uceda, is an acknowledged marine biologist and was director of the Spanish Oceanographic Institute in Santander.

Antonio graduated with honours in Geological Sciences from the Complutense University of Madrid in 1965; in 1970 he presented his PhD thesis in the same institution, under supervision from José María Fúster Casas, also obtaining honours. The focus of his thesis was a geological and petrological study of plutonic rocks in the basal complex in La Gomera Island, in the Canary archipelago (Cendrero, 1971a). His academic career has been recognised with some of the most important national and international grants (Juan March Foundation Scholarship Grant for studies in Spain, 1967; Dartmouth College (USA) postgraduate scholarship, 1967-68; Alonso de Herrera Patronage Complementary Scholarship, CSIC, to study in USA, 1967-68; Researcher Training Fellowship Program, 1969-70; Fulbright-Hays Postdoctoral Fellowship, USA, 1974.

From the same year (1965) in which Antonio graduated until 1967, he was Assistant Lecturer in the Complutense University of Madrid, whilst, with a Higher Level Contract, worked on various research projects in the Spanish National Research Council (CSIC). From 1967 to 1968, as a visiting predoctoral scholar, he worked as a Assistant Lecturer in Dartmouth College, USA. On his return to Spain in 1968, and up to 1970, he resumed teaching in the Complutense University, as a Contracted Lecturer, and as a research fellow in the CSIC (Higher Level Contract). From 1970 to 1971 Antonio worked as a lecturer in the University of Sulaimani, Iraq. In 1971 he was granted by public examination the position of Associate Professor in the University of Cantabria, and in 1977 that of Professor, in the same university

Antonio has spent numerous spells in different international universities and institutions; the previously mentioned periods in Dartmouth College (1967-1968) and the University of Sulaimani (1970-1971) as well as others in American and European universities. Some of these have been highly important when establishing the evolution of his academic and scientific career, in which three principal phases can be identified in relation to the evolution of his professional focus and interests. Firstly, the first period was dedicated to petrology and volcanology, marked by his work with Fúster and his PhD thesis (1965-1974). A second period was governed by his fellowship in the Bureau of Economic Geology, University of Texas, Austin (1974), where he came into contact with the new and wide-reaching field of Environmental Geology. On his return to Spain, Antonio carried out a carrying out pioneering

and fruitful research and diffusion of this new discipline. The highlights and milestones of this period are the founding of the Spanish Society of Environmental Geology and Spatial Planning, of which he was the first president, and his role in the Organising Committee of the I National Meeting of Environmental Geology and Spatial Planning in Santander in 1980. In addition to this, Antonio played an important part in the development of the discipline in Europe, together with notable scientists such as Lüttig, Wolff and De Mulder; a result of which was the creation, in 1990, of the Commission on Environmental Geology and Environmental Planning of the International Union of Geological Sciences (COGEOENVIRONMENT) of which Antonio was the first vicepresident.

Continuing within the field of environmental geology, Antonio starts to focus on new lines of research in natural risks and risks related to the problems of global change, such as the man's role in the magnitude of these changes and the connecting geologic processes. His fellowships in California State University (Long Beach, USA) in 1994-95, the Autonomous University of Baja California (Ensenada, Mexico) in 1994, and lastly, in the National University of La Plata (La Plata, Argentina) in 2001-2002, stand out in the third phase of his long academic and research career.

During the 41 years (1971-2012) in which Antonio Cendrero has carried out his academic and research work at the University of Cantabria, he has supervised a total of 10 PhD Thesis (Díaz de Terán, 1985; Alonso Herrero, 1987; Francés, 1987; Rivas, 1991; Salas, 1993; González Díez, 1995; Remondo, 2001; Weischelgartner, 2002; Bruschi, 2007; Dantas-Ferreira, 2008). Within the Departamento de Ciencias de la Tierra y Física de la Materia Condensada (DCITIMAC) of the Universidad de Cantabria, he has lecture mainly on Geology, Geophysics, Environmental Geology and Geological Hazards. He also has given postgraduate courses in the University of Cantabria, as well as in other European an American Universities (Salta, La Plata, Tucumán, Mar del Plata, Rio Cuarto, Rio de Janeiro, Ensenada (Baja California), Lima and Prague). Likewise, he has been lecturer in different academic spheres and institutions (Ensenada (Mexico), Bogotá, Medellín y Pereira (Colombia), Buenos Aires, Salta, Tandil y Rio Cuarto (Argentina), Rio de Janeiro y Goiás (Brazil); Montevideo (Uruguay), Lima (Peru), Guayaquil (Ecuador), Managua y León (Nicaragua), San José (Costa Rica), Allahabad (India), Beijin (China), Amsterdam, Delft y Enschede (The Nederlands), Berlin (Germany), Lisboa, (Portugal), Nantes y Granville (France), Florence and Cortina D'Ampezzo (Italia), Long Beach (USA), Viena y Dornbirn (Austria), Prague (Chec Republic), Mamaia (Rumania), Lomé (Togo), Addis Abeba (Etiopia)).

In 2000 he was elected Permanent Member of the Spanish of Royal Academy of Exact, Physic and Natural Sciences. Prof. Cendrero is also member some of the most relevant Spanish and foreign scientific societies (International Association of Geomorphologists, American Association for the Advancement of Science, Mineralogical Society of America, Geological Society of America, British Quaternary Research Group, Societé Géologique de France, Indian Association of Geomorphologists, Sub-Commission on Maps of Environmental Geology (CGMW-IUGS), Sub-Comission on Applied Quaternary Research (INQUA), European Union of Geosciences, Real Sociedad Española de Historia Natural, Sociedad Geológica de España, Sociedad Española de Geomorfología, Asociación Española para el Estudio del Cuaternario, Sociedad Española de Geología Ambiental y Ordenación del Territorio).

Throughout his extensive academic life he has been member of very different organizations and committees, both national and international (Vice-president, Commission on Earth Sciences for Environmental Planning and Management, International Union of Geological Sciences, 1990-94; Executive Comitee. Centre Européen pour les Risques Géomorphologiques, European Council, Strasbourg, 1990-93; Scientific Committee. Centro Internazionale di Studi Giuridici e Politici sull'Ambiente. Florence, 1990-92; Representing

member of the IUGS ("International Union of Geological Sciences") and UIP (Universidad Iberoamericana de Postgrado) during the United Nations Conference on Environment and Development, Rio de Janeiro, 1992; Vice-President. Centre d'Activités de Recherche Multidisciplinaire et d'Etudes sur le Littoral. EUROCOAST, La Seyne sur Mer, 1993-98; Commission on Engineering and Environmental Geological Maps. International Association of Engineering Geology, 1992; Commission on Applied Quaternary Research, INQUA, 1992-97; Working Group on Environmental Geoindicators, IUGS, 1992-96; Expert Pannel of the ALFA Programme (European Commission) for the adaptation of Sciences and Engineering universitary curricula in Latin America and Europe, 1994-97; Evaluation expert for the Environment Programme, (climatic change and natural hazards) and ENRICH, European Commission, 1993, 94, 97, 98; Representative of the International Union of Geological Sciences at the SCOPE General Assembly (Scientific Committee on Problems of the Environment, International Council of Scientific Unions), 1996-98; Member of the Steering Committee of GTOS (Global Terrestrial Observation System, FAO, ICSU, UNEP, UNESCO, WMO), 1996-98; Member of the Advisory Committee, Centre of Excellence for Research on the Abiotic Environment, Geological Survey of Poland; Member ot the Advisory Scientific Committee of the Environmental Department of Spain.

His scientific output is immense, as a consequence of his long and fruitful academic career, through which he has participated as coordinator or researcher in 35 projects, many of which have resulted in more than 260 national and international scientific publications. Some of those publications constitute relevant milestones because of the matter dealt, setting out new problems, or even contributing with ideas and methods to be carry out from a novel perspective. His principal lines of research have aimed the following subjects: Geology of volcanic regions; environmental analysis, assessment, planning and management; geoenvironmental mapping; Natural Hazards analysis and assessment (mainly, geomorphic and littoral); interactions between human activity and terrestrial processes; geomorphic processes and global change; indicators and indexes for sustainable environmental quality assessment and monitoring.

The first steps in his research activity, and obviously his initial scientific outputs, are related to petrology and volcanology, from 1966 to 1972, standing out his collaboration as co-author of 12 sheets of the Geological Map of Spain 1:50,000, corresponding to different Canary Islands (Fúster, Cendrero, Sagredo and Sánchez, 1967**;** Fúster, Cendrero and Sagredo, 1967a; Fúster, Cendrero and Sagredo, 1967b; Fúster and Cendrero, 1967; Fúster, Cendrero, Hernández-Pacheco, Páez and Sagredo, 1967; Fúster, Aguilar, Agostini, Bravo, Castañón, Cendrero, Coello, Sánchez and López, 1967; Fúster, Aguilar, Cendrero, Hernández-Pacheco and López, 1967; Fúster, Agostini, Aguilar, Bravo, Castañón, Cendrero, Hernández-Pacheco and López, 1967; Fúster, Alonso, Cendrero, Gastesi, Hernández-Pacheco, Muñoz, Sánchez, Agostini, Aguilar, Bravo and López, 1967; Fúster, Cendrero and Sagredo, 1967; Fúster, Cendrero, Gastesi, Araña, Navarro, Bravo and Coello, 1968; Fúster, Alonso, Araña, Cendrero and Navarro, 1968). Likewise, other remarcable contributions are his works on the volcano-plutonic complex of the La Gomera Island (Cendrero, 1970), on the geology and volcanology of the Canaries (Fúster, Cendrero, Gastesi, Ibarrola y López, 1968) and his publications on the geology of the Iraki Kurdistan (Cendrero, 1971a; Cendrero, 1971a). Chronologically away from this first stage but focus on the same subject matter are the publications on the genesis and chronology of the Canary volcanic eruptions (Cantagrel, Cendrero, Fúster, Ibarrola, and Jamond, 1984; Ancochea, Cendrero, Fúster, Ibarrola, Coello, Hernán, Cantagrel and Jamond, 1989; Ibarrola, Ancochea, Casquet, Fúster, Hernán, Cendrero, Díaz de Terán, Cantagrel, Jamond, 1989; Casquet, Ibarrola, Fuster, Ancochea, Cantagrel, Jamond, Cendrero, Díaz de Terán, Hernán, 1989**;** Ancochea, Fuster, Ibarrola, Coello, Hernán, Cantagrel, Jamond, Cendrero, 1989**;** Fúster, Ancochea, Ibarrola, Coello, Hernán, Cantagrel, Jamond,

Cendrero, 1989**;** Ancochea, Fuster, Ibarrola, Cendrero, Coello, Hernán, Cantagrel and Jamond, 1990; Coello, Cantagrel, Hernán, Fúster, Ibarrola, Ancochea, Casquet, Jamond, Díaz de Terán and Cendrero, 1992; Ancochea, Hernán, Cendrero, Cantagrel, Fúster, Ibarrola and Coello, 1994), as well as on the relations between eruptive dynamic and consequent surface processes (Thouret, Cendrero, Janda, Pierson et Calvache, 1987).

His outstanding contribution to the Environmental Geology in Spain, and to environmental problems in general, start with two publications (Cendrero, 1975a, c), the first in the prestigious journal Environmental Geology and the second depicts the inaugural lecture of the 1975-1976 academic year at the University of Santander in those days. Both early publications were complemented with other published shortly after in the volume of the I Reunión Nacional de Geología Ambiental y Ordenación del Territorio (Cendrero, 1980a), in which doctrinal and methodological basis of Environmental Geology were established. Meanwhile, two papers in the journal Landscape Planning come out, one present the basis of what become known as the System of the University of Cantabria for Geoscientific Mapping (Cendrero, Saiz and Díaz de Terán, 1976), and the other one (Cendrero, Antón and Saiz, 1977) deals with a slope stability problem in a new highway. The numerous works related to land planning appear in very varied publications (Escribano, Cendrero et al., 1978; Cendrero, A. Ramos y C. Steinitz (eds.), 1979; Cendrero, 1980b; Cendrero, et al., 1980; Cendrero et al., 1982; Cendrero, 1982a; Cendrero, 1982b; Cendrero, 1982c; Cendrero y Trilla, 1983; Cendrero, Díaz de Terán y González Lastra, 1984; Águeda, Cendrero et al., 1984; Cendrero et al., 1986; Cendrero and Díaz de Terán, 1987; Cendrero, Elízaga y Gallego, 1987; Cendrero, 1989a; Cendrero, 1989b; Cendrero, 1989c; Cendrero, ed., 1989; Francés, Cendrero et al., 1990; Francés, Díaz de Terán, Cendrero, et al., 1990; Francés, Gómez-Orea, Cendrero et al., 1990; Francés, Díaz de Terán, Cendrero, Gómez-Orea, Vilariño, 1990; Cendrero, 1991; Cendrero, Díaz de Terán, Francés, 1994; Fischer, Rivas and Cendrero, 1995; Cendrero, 1995; González-Díez, Cendrero et al., 2000).

A very important facet of the academic activity of Antonio Cendrero is linked to teaching and didactics of Geology and Natural Environment in the different levels of education, as well as the spreading to the general public. The period in which he was the director of the *Instituto de Ciencias de la Educación* (Educational Sciences Institute) of the former University of Santander (1973-1978) meant the introduction, in the different levels of education, of novel teaching methods and techniques, among other subjects programming by objectives (Cendrero, Caloca and Ramos, 1979; Cendrero, 1980; Agudo, Cendrero et al., 1980c; Agudo, Cendrero et al., 1980d; Antón, Cendrero, Díaz de Terán and González, 1982; Cendrero, Díaz de Terán, Flor and González, 1982; Cendrero and González, 1983; Cendrero, Díaz de Terán, González and Flor, 1983; Cendrero, Díaz de Terán, Francés, González and Loriente, 1983; Cendrero, Francés, Manso and Martín, 1984; Cendrero, Díaz de Terán and Fernández, 1984; Cendrero, 1985; Moreno and Cendrero, 1987; Cendrero, 1989; Cendrero, 1992; Cendrero et al., 1993; Barba, Díaz de Terán, Salas, Cendrero and Valdeolivas, 1996).

Geological heritage inventorying, assessment and management have been also relevant and constant aims. In this sense, his work in this field has been pioneer in the country and was decisive for the program of inventorying and cataloguing of Geological Sites in Spain undertaken by the Instituto Geológico y Minero de España (Geological Survey of Spain) and precisely initiated in the Eastern Sector of the Cantabrian Range (IGME, 1983; Puntos de Interés Geológico en el Sector Oriental de la Cordillera Cantábrica). Many of the collection works previously carried out in the Department were the basis for the selection of the most relevant geological sites of the Cantabrian Range, and gave rise to a series of publications, spreading maps, methodologigical approaches for the study of the natural heritage and a PhD thesis (Cendrero, Díaz de Terán, Flor and González, 1982; Cendrero and González, 1983; Cendrero, Díaz de Terán, González and Flor, 1983; Cendrero, Díaz de Terán, Francés,

González and Loriente, 1983; Cendrero, Francés, Manso and Martín, 1984; Cendrero, Díaz de Terán and Fernández, 1984; Cendrero et al., 1986; Moreno and Cendrero, 1987; Cendrero, Díaz de Terán and Francés, 1991; Cendrero et al., 1993; García, Gallego, Palacio, Cendrero, Elízaga, Cabra, 1993; Cendrero, 1996a; Cendrero, 1996b; Cendrero, 2000; Bruschi, Cendrero, Cuesta-Albertos, 2011; Bruschi, 2007).

In the late eighties and early nineties of the last century, he focuses on Quaternary and Geomorphology, in particular on surface processes such as those related to slope evolution, coastal dynamics, etc. (Moñino, Cendrero and Díaz de Terán, 1987; Rivas and Cendrero, 1987; Moñino, Díaz de Terán and Cendrero, 1988; Cendrero, Díaz de Terán and Otamendi, 1988; Moñino, Cendrero and Díaz de Terán, 1988; Moñino, Ortega, Cendrero and Díaz de Terán, 1988; Cendrero, Díaz de Terán, Moñino, 1988; Salas and Cendrero, 1989; Rivas and Cendrero, 1990; Rivas and Cendrero, 1991; González, Díaz de Terán and Cendrero, 1992; Rivas and Cendrero, 1992a; Rivas and Cendrero, 1992b; Cendrero, et al., 1994; González, Salas, Cendrero, Remondo and Díaz de Terán, 1996; González, Salas, Díaz de Terán and Cendrero1996; Cendrero and Dramis, 1996; Soto, Gómez, Ródenas and Cendrero, 1997; González, Remondo, Díaz de Terán and Cendrero, 1999; Soto, Gómez, Cendrero et al., 2000; Gutiérrez, Galve, Guerrero, Lucha, Cendrero et al., 2007).

From an early stage, he has shown interest in natural hazards, from the viewpoints of both assessment and modelling (Cendrero et al., 1987a; Cendrero et al., 1987b; Cendrero et al., 1987c; Díaz de Terán and Cendrero, eds., 1992; Cendrero, 1992; Cendrero, 1994; Cendrero, 1995; Remondo, Díaz de Terán, Cendrero et al., 1996; Cendrero, 1997; Díaz de Terán, Cendrero et al., 1997; Remondo, González, Díaz de Terán, Cendrero, Fabbri, Chung, 2003; Remondo, González, Díaz de Terán, Cendrero, 2003; Fabbri, Chung, Cendrero, Remondo, 2003; Remondo, Bonachea, Cendrero, 2004; Bonachea, Remondo, Cendrero, 2004; Remondo, Bonachea, Cendrero, 2005; Remondo, Bonachea, Cendrero, 2008; Galve, Bonachea, Remondo, Gutiérrez, Lucha, Cendrero, Gutiérrez and Sánchez, 2008; Bonachea, Remondo, González, Díaz de Terán, Cendrero, 2009; Galve, Gutiérrez, Lucha, Bonachea, Remondo, Cendrero, Gutiérrez, Gimeno, Pardo, Sánchez, 2009; Galve, Gutiérrez, Cendrero, Remondo, Bonachea, Guerrero, Lucha, 2009; Bonachea, Remondo, Díaz de Terán, González, Cendrero, 2009; Galve, Gutiérrez, Lucha, Guerrero, Remondo, Bonachea, Cendrero, 2009; Galve, Gutiérrez, Bonachea, Lucha, Remondo, Cendrero, Gutiérrez, Gimeno, Pardo, Sánchez, 2009).

Environmental impact assessment for land planning and management, the assessment of potential impacts, as well as the use of indicators and indexes to evaluate sustainability have been also of interest, both regarding methodological proposals and their application in particular case studies (Cendrero, 1989; Francés, Cendrero, Morey, 1989; Cendrero and Charlier, 1989; Alonso, Francés and Cendrero, 1990; Francés, Díaz de Terán y Cendrero, 1990; Díaz de Terán, Francés, Duque and Cendrero, 1992; Cendrero, 1994; Rivas, González, Fischer and Cendrero, 1994; Rivas, Fischer and Cendrero, 1994; Rivas and Cendrero, 1995; González, Díaz de Terán, Francés and Cendrero, 1995; Rivas, Rix, Francés, Cendrero and Brunsden, 1995; Fabbri and Cendrero, 1995; Rivas, Rix, Francés, Cendrero and Brusden, 1997; Cendrero, 1997; Cendrero and Fischer, 1997; Cendrero and Panizza, 1999; Cendrero, 2000; Bertens, Tamés, Cendrero and van Asch, 2000; Cendrero, Marchetti, Panizza and Rivas, 2001; Cendrero et al., 2002; Cendrero et al, 2003; Cecioni, Pineda, Cendrero, Hurtado, Panizza, 2004; Otero, Bruschi, Cendrero, Iglesias, Lázaro, Togores, 2004; Bonachea, Cendrero et al., 2005; Cendrero et al., 2005).

Global Change, the influence of man on the magnitude of those changes and on geomorphic processes constitutes his main focus during the last years. In this sense, his speech when he joined the Real Academia de Ciencias Exactas, Físicas y Naturales was titled “De la Comprensión de la Historia de la Tierra al Análisis y Predicción de las Interacciones Entre

Seres Humanos y Medio Natural" ("From the understanding of the History of the Earth to the Analysis and prediction of the Interactions between human and Natural Environment") (Cendrero, 2003); his contributions on this subject matter is broad (Rivas y Cendrero, 1996; Cendrero, 1997; Cendrero, 2000; Rivas, Remondo, González y Cendrero, 2002; Cendrero and Remondo, 2002; Remondo, González, Soto, Díaz de Terán, and Cendrero, 2005; Cendrero, Rivas, Remondo, 2005; Rivas, Cendrero et al., 2006; Cendrero et al., 2006; Cendrero, Remondo, Bonachea, Rivas, 2006; Cendrero et al., 2007; Cendrero, Bonachea, Remondo, 2009; Cendrero et al., 2010).

Many other subjects are reflected in his bibliographic production. For example, the processes of anthropic fill in the Cantabrian estuaries (Cantabrian sea) and their environmental consequences (Cendrero y Díaz de Terán, 1977; Cendrero, Díaz de Terán and Salinas, 1981; Rivas y Cendrero, 1992; Rivas y Cendrero, 1993), the deterioration of the paintings of the Altamira cave in conection with the geology of the cave (Valle, Moya y Cendrero, 1978; Valle, Moya y Cendrero, 1979), survey of archaeological sites by means of geophysical techniques (Cendrero y Martínez, 1985), the glaciarism in the Cantabrian Range (Moñino, Díaz de Terán y Cendrero, 1988; Moñino, Cendrero y Díaz de Terán, 1988), and even the book "Guía de la Naturaleza de Cantabria" (Guide book of the Cantabria Nature") (Cendrero et al., 1986) with three editions but difficult to buy currently.

Finally, this account would be incomplete if two relevant merits, concerning the more human and personal side of Antonio Cendrero, are omitted. One is his demonstrated ability as organizer and host of the "weekend seminars" to play mus (Spanish card game), which are being never-ending held for several years in his home, bringing together around the game table a selected group of experts in the discipline, all of them announced by Prof. Cendrero (some disciples, interested in taking part in the circle, await with impatience the publication of the "minutes" of such momentous meetings. The other one is related to the "sustainable gardening", successful activity initiated several decades ago in the small wood surrounding his house, resulting in the maintenance of the native vegetation of the area (including the associated fauna), which also supply the combustible required for the chimney of the living room of his home (Antonio Cendrero, personal communication).

A list of his publications and doctoral thesis supervised are presented somewhere above in this volume.

Santander, September, 2012

From environmental geology to global geomorphic change

Scientific Simposyum in honour of Prof. Antonio Cendrero

Santander, September 21st, 2012

PROGRAM

9:00-9:30 Reception

9:30-10:00 Opening ceremony

10:00-10:30 Coffee break

10:30-13:00 Oral presentations

10:30-10:40: G. Benito, V.R. Thorndycraft, M.J Machado, M. Rico, Y. Sánchez-Moya, A. Sopeña. Discerning climatic and environmental change signals on palaeoflood records.

10:40-10:50: A. Cearreta, E. Leorri. Can recent sea-level rise be interpreted as an evidence that we are already living in the anthropocene?

10:50-11:00: M. Monge-Ganuzas, A. Cearreta, G. Evans. Morphodynamic response of coastal sand dunes in the Laida Beach (Oka estuary, Urdaibai Biosphere Reserve) after human regenerative actions (1999-2012 period). A possible relationship with current climate change?

11:00-11:10: M.J. Crozier. Human impact on landslide occurrence: a review of the New Zealand case.

11:10-10:20: M. Soldati, A. Ghinoi, S. Menoni, E. Pattuzzi. From landslide risk to resilience: the contribution of geomorphology.

11:20-11:30: J. Chacón, C. Irigaray, R. E Hamdouni, P. Fernández, J. Jiménez-Perálvarez, J.A. Palenzuela, P. Alameda. Recent advances on landslide diachroneity, activity and hazard in the Betic Cordillera.

11:30-11:40: J. Moya, J. Corominas, O. Mavrouli. A probabilistic approach to the number and size of blocks of fragmental rockfalls.

11:40-11:50: R. Menéndez-Duarte, D. Vázquez-Tarrio, A. Colubi. Soil creep and soil slides: favorability values of geological, vegetation and relief factors and a multinomial logistic regression model.

11:50-12:00: F. Gutiérrez, D. Carbonel, R. Linares, C. Roqué, M. Zarroca, J. Guerrero, V. Rodríguez, M. Gutiérrez. Differentiating between gravitational and tectonic faults, the case of the Zenzano Fault (Iberian Chain, N Spain).

12:00-12:10: A. Suma, F.J. Gracia, P. de Cosmo. Neotectonic controls on the origin and evolution of karstic poljes in the Sierra de Grazalema, Ronda Massif (Betic Ranges, SW Spain).

12:10-12:20: P. Farias-Arquer, J. Gallastegui, J. Olona, J.M. González-Cortina, G. Fernández-Viejo, C. López. Geological and geophysical study on the causes of the Andara Lake draining (Picos de Europa, N Spain).

12:20-12:30: D. Castaldini, P. Di Manna, L. Piccardi, L. Guerrieri, E. Vittori, A. Berlusconi, L. Bonadeo, V. Comerci, F. Ferrario, R. Gambillara, F. Livio, M. Lucarini, M.

Michetti Alessandro, G. Tosatti. Geological and geomorphological aspects related to the 2012 seismic sequence in the Central-Southern Po Plain (Northern Italy).

12:30-12:40: M. Jiménez-Sánchez, H. Stoll, S. Giralt, A. Moreno, M.J. Domínguez-Cuesta, A. Aranburu, A. Méndez-Vicente, D. Ballesteros, B. Valero-Garcés, H. Cheng, L. Edwards. Caves as geomorphological records: the example of El Pindal cave (Cantabrian Coast, N Spain).

12:40-12:50: M. Panizza. The role of geomorphology in the management of the Dolomites (UNESCO World Heritage Site).

12:50-13:00: A.M. Martínez-Graña, J.L. Goy, C. Zazo. The landscape and geomorphology in the planning and management of natural parks. Applications in the Las Batuecas-Sierra de Francia and Quilamas natural parks, SW Salamanca (Spain).

13:00-13:10: J. Marquínez, E. Fernández-Iglesias, R. Santos-Alonso, M. Gutiérrez-García. Flood risk management in North Spain: towards more sustainable planning policies in floodplains.

13:15-13:45 Closing ceremony

14:00 Social lunch

Posters Session

M. L. de Paula Herrmann. Contributions by Professor Antonio Cendrero in the analysis of Landslides at Morro do Baú complex, Santa Catarina-BR.

G. Flor-Blanco, L. Pando, G. Flor. Progradation of beach-dune systems confined by docks in estuary mouths. Cantabrian sea (N Spain).

J. López-Martínez, J.J. Durán, L. Carcavilla, P.A. Robledo. Protected karst areas and show caves in Spain: geological heritage, conservation and socioeconomic implications.

M.J. Domínguez-Cuesta, M. Jiménez-Sánchez, L. Francos-Garrote. Slope instability triggering during a rainfall event in Asturias (Spain): an example of media impact in scientific studies.

M.L. Rodrigues. The concepts of geoheritage and geotourism.

D. Vázquez-Tarrio, R. Menéndez-Duarte. Fluvial bedload sediment transport in the Narcea River basin (NW Iberian Peninsula).

Other contributions

C.J. van Westen. The changes project: analyzing changing hydro-meteorological risk.

A. Pulido-Bosch, A. Vallejos, L. Daniele, L. Molina. Geomorphological factors of an impending disaster (Balsa del Sapo, Campo de Dalías, Almería).

J. Rodríguez-Vidal, F. Ruiz, M. Abad, L.M. Cáceres, M.I. Carretero, M. Pozo, J.M. Rodríguez-Llanes, F. Gómez-Toscano. Geomorphological markers of Holocene tsunamis in the estuaries of Southwestern Spain: human implications.

J. Weichselgartner. Vulnerability of coastal zones: driving forces and pathways for reduction.

L.M. Forte, J. Remondo, A. Cendrero. Trends in the intensity of geomorphic processes during the 20th Century. Implications for the starting point of the anthropocene.

CONTRIBUTIONS

DISCERNING CLIMATIC AND ENVIRONMENTAL CHANGE SIGNALS ON PALAEOFLOOD RECORDS

G. Benito*, V.R.Thorndycraft, M.J Machado*, M. Rico***, Y. Sánchez-Moya****, A. Sopeña******

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Abstract: Interpretation of palaeohydrological changes from alluvial sequences is a complex task because of problems in the identification of their causation (climate vs. land-use change) in a region with a long history of human intervention. During the last decade there has been increasing interest in applying palaeoflood hydrology for the record of individual floods (magnitude and frequency) during the Holocene. This presentation will review the results of these analyses and evaluate changes in the spatial and temporal distribution of floods in the Spain over the last 2000 years on the bases of radiocarbon dating and environmental (documentary) history. In the Iberian Peninsula, increased flood frequency and magnitude were identified in the sedimentary record at AD 1000-1150, 1430-1700 and 1730-1800; though chronological resolution using radiocarbon dating during the last 300 years is relatively poor. The largest historical flood peak discharges since AD 1500 occurred when the North Atlantic Oscillation during the winter months was in its negative phase. In Iberian Mediterranean catchments, documentary sources indicate highest flood severity during AD 1580-1620 and AD 1840-1870. The lack of slackwater deposits between AD 1200 and 1400 highlights as a period of particularly low frequency of large floods, and is also evident in the documentary record. However, this period (1150-1450 cal. AD) comprises one of the main phases of historical floodplain aggradation of Iberian rivers that has been interpreted as a result of land-use changes. This phase of accelerated alluviation during the late medieval period is ubiquitous in Spanish rivers, and commonly resulted in the burial of irrigation structures and dams. At site-specific records (e.g. Guadalentin River), palaeoflood records indicate an anomalous increase in the frequency of large magnitude floods between AD1830-1900, which was attributed to climatic variability accentuated by intensive deforestation and land-use practices during the first decades of the 19th century. However, this late Agricultural Revolution was not synchronous all over Spain, and periods of high sediment production associated to floods may started earlier in other Mediterranean rivers (e.g. Rambla de la Viuda in Castellón).

CAN RECENT SEA-LEVEL RISE BE INTERPRETED AS AN EVIDENCE THAT WE ARE ALREADY LIVING IN THE ANTHROPOCENE?

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Abstract: The Anthropocene is a term widely used since its coining by Paul Crutzen and Eugene Stoermer in 2000 to denote the present time interval, in which many geologically significant conditions and processes are profoundly altered by human activities. The beginning of the Anthropocene is most generally considered to be at ca AD 1800, around the beginning of the Industrial Revolution in Europe. A proposal to formalize the Anthropocene within the Geological Time Scale is being developed by the Anthropocene Working Group of the Subcomission on Quaternary Stratigraphy. The Anthropocene is currently being considered as a potential geological epoch, at the same hierarchical level as the Pleistocene and Holocene epochs, with the implication that it is within the Quaternary Period but that the Holocene has terminated. To be accepted as a formal term the Anthropocene needs to be (a) scientifically justified (i.e. the "geological signal" currently being produced in strata now forming must be sufficiently large, clear and distinctive) and (b) useful as a formal term to the scientific community. In this sense, the currently informal term Anthropocene has already proven to be very useful to the global change research community. Contemporary sea-level rise is anomalous in the context of late Holocene sea-level change. The absence of significative pre-20th-century sea-level fluctuations in proxy records suggests the 20th century sea-level acceleration was unprecedented in (at least) the past millennium. Coastal sediment cores (palaeosea-level data), the few long (pre-AD 1900) tide-gauge records, reconstructions of the 20th-century sea levels, and satellite altimetry data all indicate that the rate of sea-level rise has increased by about an order of magnitude: from at most a few tenths of a millimetre per year over previous millennia to about 1.7 mm year-1 during the 20th century and to over 3 mm year-1 since 1993. The main feature common to all these estimates is a higher rate of rise during the 20th century compared with the late 19th century. Salt marsh sediments can produce proxy records with a precision of ±10 years in the 19th century and ±5 years in the 20th century depending on sedimentation rate and sampling resolution. This is considerably lower than observational records. However, it has potential to extend the tide-gauge data set both spatially and backward in time. The most effective methods for detailed analysis of salt marsh stratigraphy involve microfossils. Marsh foraminiferal assemblages record the degree to which the salt marsh surface is able to maintain its position relative to a rising sea level. Higher marsh (less frequently inundated) foraminiferal assemblages occur when marsh accretion is faster than the rate of sea-level rate. Lower marsh assemblages appear when sea level rises faster than the rate at which marsh sediments accumulate. This method works best in regions where relative sea level is rising, so that accommodation space is created in which the salt marshes can accrete vertically. Dating of these recent sediments can be performed by radiometric analyses (^{14}C, ^{210}Pb) and stratigraphic marker techniques (e.g., ^{137}Cs, pollen, PAHs, Pb isotopes, metal concentrations). Main areas of uncertainty are concentrated on a) the initiation of the 20th century sea-level rise, as a growing number of high-resolution records detect an acceleration in sea level dated between AD 1880 and 1920, and despite carbon dioxide levels began to rise in the late 18th century; and b) the patterns of regional variations in the rate of sea-level rise, as it is the relative sea-level change (global+regional+local components) that impacts the environment and society.

TRENDS IN THE INTENSITY OF GEOMORPHIC PROCESSES DURING THE 20TH CENTURY. IMPLICATIONS FOR THE STARTING POINT OF THE ANTHROPOCENE

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Abstract: In the last few years a series of concepts such as the *geomorphic dimension of global change*, *global geomorphic change*, *human geomorphic footprint* or *human geomorphic pressure*, have been proposed to bring attention on the effects of a profound modification of the Earth's surface, likely to be of global extent. This modification, due to growing human pressure derived from population increase as well as increasing economic and technological capabilities, appears to be producing an important intensification of geomorphic processes. This, in turn, is reflected in greater sediment generation and sedimentation rates, as well as greater frequency of geomorphic hazard and disaster events.

This contribution presents global data on the geographic and temporal distribution of different types of natural disasters and sediment generation/deposition rates. Comparisons and correlations with different potential driving agents, both natural (rainfall) and human (intensity of human activities, land degradation), are carried out and discussed.

The results obtained show that geomorphic processes have experienced what appears to be a worldwide acceleration. The analyses carried out do not show a significant correlation with rainfall, but in most regions of the world do show high correlation coefficients (in some cases greater than 0.9) with indicators of human influence on land surface. The starting point of the acceleration described was around the middle of last century, coinciding with the "Great Acceleration" of Steffen et al. (2011). The results presented here strongly suggest that one of the characteristics of the Anthropocene is a considerable increase of the intensity of geomorphic processes. It is suggested, on the basis of this and other changes, that it would perhaps be better to consider that the Anthropocene started at the end of World War II, rather than the beginning of the Industrial Revolution.

MORPHODYNAMIC RESPONSE OF COASTAL SAND DUNES IN THE LAIDA BEACH (OKA ESTUARY, URDAIBAI BIOSPHERE RESERVE) AFTER HUMAN REGENERATIVE ACTIONS (1999-2012 PERIOD). A POSSIBLE RELATIONSHIP WITH CURRENT CLIMATE CHANGE?

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Abstract: Sand dunes are rare along the Cantabrian coast as it is dominated by steep cliffs and is an erosional coastline. Furthermore, the small embayments in which dunes have been able to develop have been destroyed or severely modified during the last 200 years. Due to their important ecological as well as protective role the conservation, regeneration and maintenance of this unique ecosystem has become a subject of great interest.

In 1999 the Governing Board of the Urdaibai Biosphere Reserve decided to regenerate the coastal sand dunes that had existed previously until the 1950´s in the mouth of the Oka estuary. Together with the restoration a morphodynamic monitoring programme has been implemented over the last 13 years in an attempt to understand and evaluate the dominant physical processes controlling dune development.

Summer (May-October) is characterized by low intensity sea-wave action and winds of low intensity. Sand is supplied to the dunes of Laida beach, on the eastern side of the estuary, from a system of three ridges developed by breaking waves and tidal currents. These ridges migrate inland across the intertidal zone and lead to a large accumulation of sand on the beachface which progrades seawards during this season. During this season the ebb delta of Mundaka bar on the west of the estuary extends seawards.

Winter (November-April), on the other hand, is characterized by increased wave energy (swell-wave action) as well as increased wind intensity. Laida beach is eroded at this time and sand is transported to the offshore subtidal area, away and also into the estuary to form a flood delta. The beach profile is markedly steepened during this season and the bars disappear from the low tide terrace which assumes a flat rippled morphology. In addition the increased wave and tidal energy erode the ebb tidal delta and alter its morphology.

Sand is transported to the dune system of Laida beach by winds coming from the North and South when velocities exceed 4 m/s where it is trapped by vegetation. Northerly winds are more frequent than others, however, these are normally associated with rainy weather and their transport capacity is less than that Southerly winds which are related to high pressure and drier weather and hence lead to a much greater transport. The bimodal nature of the wind produces a stationary sand body with a symmetrical morphology.

In 2003 Laida beach was widened by the deposition of 243.000 m^3 of sand over its intertidal and supratidal zones. Later, lines of fences were erected to trap sand mobilized and transported by wind action. Initially these was merely aggradation and after burial of the fences sand accumulations prograded to the north and south depending upon the wind direction. Later, vegetation such as *Ammophila arenaria* and *Elymus farctus* were planted and the sand dune complex grew to a volume of 44.000 m^3 over an area of 82.000 m^2 and reached heights of approximately 2,5 m. Since the original dumping of sand in 2003 large scale erosion has occurred around the limits of the dune system due to wave and tidal current activity and during recent years increasing erosion has dramatically reduced the supratidal area of Laida beach. This recent erosion is perhaps related to current sea-level rise (2 mm/per year) and the increased intensity and periodicity of gales in the Bay of Biscay during winter.

In summary, the natural changes which occur on Laida beach are produced by varying waves, tides and winds which control its morphodynamic evolution. Human induced changes have caused the system to react to restore the previous natural equilibrium condition. The coastal complex in the Oka estuary has always been constituted by the same sedimentary elements (beach, inlet, flood ebb deltas and dunes). However, these individual elements have exhibited a great variability at various scales, daily to annually, although always maintaining a dynamic equilibrium that can be at present unbalanced again due to climate change or further anthropogenic activity.

THE CHANGES PROJECT: ANALYZING CHANGING HYDRO-METEOROLOGICAL RISK

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Abstract: Environmental changes due to global change and resulting reactions in ecosystems, combined with expected changes in socio-economic development will lead to adjustments in land use in areas that are exposed to hydro-meteorological hazards such as flooding, mass movements, severe erosion, snow avalanches and wind storms. These hazards will also have domino effects (e.g. the effect of land-use change on runoff severe erosion and consequent landslides and river damming leading to flooding) that are still not properly understood. The effects of these changes need to be analyzed and modeled with probabilistic hazard and risk methods that can be used by stakeholders from different sectors. The probabilistic models should incorporate the uncertainties in temporal probability, spatial extend and magnitude of the hazards, as well as the uncertainties of the vulnerability of the exposed elements at risk. The modeled changes in hazard and risk patterns need to be incorporated into disaster risks management strategies and will form an important factor in land use planning activities at stakeholder relevant levels. They also have a large impact on risk governance policies that need to be adapted.

This paper gives an overview of work related to the analysis of changes in hydro-meteorological risk in Europe, focusing on analysis of changing hazards, changing exposure of elements at risk, and their vulnerabilities. The structure and workplan of a recent EU FP7 Marie Curie Initial Training Network called "CHANGES" is presented. This project (Changing Hydro-meteorological Risks – as Analyzed by a New Generation of European Scientists) intends to develop an advanced understanding of how global changes (related to both environmental and climate change as well as socio-economical developments) will affect the temporal and spatial patterns of hydro-meteorological hazards and associated risks in Europe, how these changes can be assessed, modeled and how these can be incorporated in sustainable risk management strategies, focusing on spatial planning, emergency preparedness and risk communication. The project involves 12 PhD researchers and 3 postdocs, and includes 11 partners and 6 associated partners. The project website is: www.changes-itn.eu.

HUMAN IMPACT ON LANDSLIDE OCCURRENCE: A REVIEW OF THE NEW ZEALAND CASE

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Abstract: Despite a very short history of human occupation, New Zealand has experienced dramatic landscape change. Two thirds of the temperate rainforest which covered 85% of New Zealand has been destroyed, much of in the last 160 years as European colonists converted forest to pasture for sheep farming. Most of the steepland country below 1000m in altitude used for farming (40% of New Zealand) suffers from landslide erosion. This paper reviews the results of research that have attempted to isolate the factors responsible for erosion, assess rates and quantify the effects of land use change. Historic observations show that a new phase of severe landslide erosion was initiated by conversion of forest to pasture farmland. This phase of erosion is referred to as 'regolith stripping', as successive events have been capable of removing over half of the regolith cover from catchments within the space of one hundred years. The pattern of regolith removal and re-deposition, as well as material and landform changes brought about by successive landslide events, form the basis of a conceptual catchment evolution model. Paired catchment studies that record the area eroded by landslides under different vegetation covers during a given event indicate that landslide erosion on pasture is 3 – 10 times greater than under forest. A seven thousand year sedimentation record from one lake located within severely eroded steepland provides information on conditions under indigenous temperate rain forest, the first effect of Polynesian land use (about 500 y BP) and most dramatically (from about 1880AD), the impact of European conversion of forest to pasture. The most recent analysis of this record indicates that, while large landslide events have occurred throughout the entire record, the pre-European period provides sedimentation rates of only 3.3 mm per year compared to the post European period that has rates of >10 mm per year. In contrast to earlier studies, neither storm frequency nor sedimentation show any correlation with the El Niño Southern Oscillation. Polynesian land use practices appear to have produced only a small elevation in sedimentation rates. Urbanisation in New Zealand, as with most countries, is an accelerating process that has the potential to affect slope satbility. Correlation of landslide distribution patterns and storm rainfall distribution has indicated that the process of urbanisation causes measurable reduction in slope stability. Continued urbanisation can be expected to increase both the landslide hazard and risk.

RECENT ADVANCES ON LANDSLIDE DIACHRONEITY, ACTIVITY AND HAZARD IN THE BETIC CORDILLERA

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Abstract: In this paper recent results on combining DInSAR, TLS and GNSS (Global Navigation Satellite Systems), with inclinometry data and historical documentation, applied to detect and assess morphological slope features, mass movements, reactivations, and differential displacements in several deep-seated landslides, are presented with a discussion of the obtained results in term of landslide diachroneity and activity with consequences for the assessment of landslide hazard in the affected areas.

The new definition of some deep-seated landslides formerly considered as “dormant” and after the new data shown as slope movements with irregular activity, alternating phases of low activity with reactivations, due mainly to heavy rainfall, and attending diachroneity scale of VIII, is detailed. The convenience of a clear differentiation between consequences of shallow and deep-seated landslides in the inventories and its treatment for landslide susceptibility mapping, as also for the assessment of landslide hazard is considered and discussed.

FROM LANDSLIDE RISK TO RESILIENCE: THE CONTRIBUTION OF GEOMORPHOLOGY

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Abstract: Lately research on global change and related impacts has significantly dealt with the effects of climate change on geomorphic processes and hazards, among which slope instability. It has been pointed out that the ongoing climate changes will cause a series of consequences on the environment as a result of variations in temperature, precipitation amount and/or intensity and consequently in soil moisture conditions. Induced geomorphological risks are expected to undergo significant increase under the changing of climate conditions, among which landslide risk. It has been proved that most landslides occur because of saturated terrain moisture conditions and by consequent loss strength, triggered by climatically-controlled processes, such as intense and/or prolonged precipitation events, rapid snowmelt, permafrost degradation or river erosion. If climate change leads to increased frequency and/or magnitude of these hydrological processes, the frequency and/or magnitude of landslides in a region will be similarly influenced. As for magnitude, the combination of higher rainfall intensity and increasing volumes of unconsolidated sediments due to glacier retreat could result in higher landslide and debris flow volumes and runout. Similarly, the combination of long-term temperature increase and high-intensity rainfall events may imply more frequent landslides over a range of volumetric scales. Finally, compound effects of climate change and human actions, where humans can act as both co-triggers and elements at risk, have proved to be frequent. In this sense, some studies highlight the fact that, beside climate variations, land use change should not be neglected in slope instability assessments.

Concerning the forecasting of future climate trends, an unavoidable reference is the Intergovernmental Panel on Climate Change (IPCC), that has recently published (March 2012) a special report on "Managing the Risk of Extreme Events and Disasters to Advance Climate Change Adaptation" (SREX). It is clear that policies of disaster risk management and adaptation to climate change should more and more focus on reducing exposure and vulnerability and on increasing resilience to the potential adverse effects of climate extremes which is fundamental to prevent disasters.

The current state-of-the-art in landslide hazard assessment offers a wide variety of methods, suitable for the analysis of different landslide types and for different scales of analysis, from the local to the regional one. According to the scale, those methods can range from pure statistical or observational (especially for large study areas) to pure deterministic, where a single landslide is investigated. Most of them are consolidated methods, both for the academic world and for practitioners. In several European regions, maps of landslide hazard are used as basic knowledge elements in territorial planning. If landslide hazard assessment can reasonably be considered as well tested and rather consolidated in practice, the ongoing climatic changes would require to approach the problem in a different way from the usual methodological approaches. In most cases, the latter are based on the assumption that triggering causes, magnitude and frequency, derived from the observation of past occurrences, will likely be the same also in the future. In this framework, landslide hazard maps make up a static picture of the expected hazard, which can be accepted only within a static morphoclimatic environment, which is not the case in many parts of the World. Thus the need for multiple landslide hazard scenarios becomes clear. Special attention should also be paid to the different types of landslides which may occur as a result of different rainfall intensity

and/or regimes, thus compelling to perform distinct landslide hazard assessments for each type of expected landslide. Since the changes in global/regional climate patterns, and in the resulting local meteorological pattern, are still not clearly defined, in hazard assessment geomorphologists should end up performing multiple-scenario analyses, taking into account the most probable precipitation patterns that may occur, being very flexible to continuously adapt to the changes occurring along the path.

However, it is well known that hazard assessment is only part of the landslide risk evaluation, which also includes the assessment of vulnerability. In recent years, an ever-growing attention has been raised in Europe, also by the geomorphological community, towards vulnerability assessment methods and, lately, also towards the assessment of resilience, which can be generally considered as the capacity of a certain community of people to face and positively react to the occurrence of a certain hazardous phenomenon. This issue has been extensively explored by the recent EC-funded ENSURE Project that aimed at elaborating a methodological framework to assess vulnerability and resilience across different temporal and spatial scales. The framework consisted in four matrices that addressed resilience and vulnerability at different phases of a disastrous event and at different spatial scales. Within matrices several indicators were identified to assess resilience and vulnerability of different systems, ranging from the natural systems, to the built environment and to infrastructures, and finally to the social and the economic systems. In addressing such a variety of systems, the framework created a bridge between the natural sciences (responsible for identifying parameters and indicators related to the natural and the built environments) and the social sciences (necessary to tackle social and economic systems' vulnerability and resilience).

A set of four matrices has been developed for different natural hazards, including landslides.

The first matrix deals with the capacity to mitigate. With respect to the elements at risk (objects and artifacts), it is checked whether or not vulnerability assessment has been carried out and taken into consideration in planning and risk prevention policies; in the case of critical facilities, not only the awareness of systemic vulnerability is taken into account, but also the ability to reduce it through programmes of ordinary maintenance and repairs to existing installations is assessed. In the second matrix, the physical propensity to damage of the natural environment, objects, critical facilities and people is assessed. All the factors shaping the potential response to the stress provoked by different types of landslides are considered, including the possibility of enchained effects both natural and na-tech (for example in the case of a dangerous plant in the path of a rapid mass movement). In the third matrix, the capacity to react to the physical losses and their consequences is addressed; secondary effects in the natural environment, with respect to artifacts, urban areas and critical facilities, the capacity to keep functioning despite some level of physical damage is evaluated, considering the interdependencies among systems and among components of vital systems. Finally, the fourth matrix concerns the recovery potential. As for the natural environment the ecological resilience is referred to, particularly for those hazardous events that may significantly disrupt the natural environment itself with permanent damage. For the built environment and the critical facilities and production sites, the capacity to embed the lessons learnt in the disaster while reconstructing artifacts and places is evaluated.

From a geomorpholgist's point of view, one of the main conclusion drawn after the implementation of the Ensure framework to a real case (the Corvara landslide in Northern Italy) is the need to reinforce hazard studies and monitoring systems and to make them part of ordinary planning and programming activities. A better balance has still to be sought between "natural" and social sciences in the development of indicators to better consider the specific challenges and constraints in order to fit vulnerability and resilience assessments to areas menaced by different types of landslides and due to varied triggering factors. The Ensure Project certainly has set the path for future research in the domain of vulnerability and

resilience assessments in the case of places threatened by landslides. On the one hand social scientists developing indicators and methodologies should be better aware of the differences existing among different types of landslide mechanisms and effects, and between the latter and those deriving from other phenomena like earthquakes or volcanic eruptions. In fact, the possibility to forecast and alert differs significantly across landslides types and this should be better perceived as it implies that in some cases alerting is possible in others not. On the other hand, also geomorphologists need to look at landslides not just as physical phenomena but rather as the result, the combination of a natural event and the exposure and vulnerability of settlements, infrastructures and communities. The way of designing settlements and the level of preparedness of authorities and population may change the potential impact in a relevant way, which must be still appreciated by “natural” scientists.

A PROBABILISTIC APPROACH TO THE NUMBER AND SIZE OF BLOCKS OF FRAGMENTAL ROCKFALLS

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Abstract: Rockfalls are frequent phenomena in steep rock slopes. Several issues on the analysis of the rockfall process have significantly been developed in the last decade, particularly the 3D simulation of the trajectory of rock blocks. Many rock masses detached from cliffs undergo fragmentation after the first impacts with the ground. Fragmentation is a complex process that has received little attention in the literature. It controls the sedimentation rate on talus slopes and the rockfall hazard. In this work, we present an approach to assess the number and size of blocks resulting from fragmentation that may be implemented in trajectographic analyses. This approach assumes that the volume of blocks resulting from the fragmentation follows a defined distribution probability, which is the same with the one observed for the blocks accumulated in the talus slope. Consequently, the volume distribution of blocks accumulated in talus slopes can be used to generate random sets of rock blocks, each one being assimilated to a rockfall event. For each event, the individual block volumes are summed until they reach the specified volume of the detached rock mass. This approach is applied to a talus deposit of the Solà d'Andorra la Vella (Andorra) and the results are compared with the volume distribution of inventoried rockfall events in the area.

SOIL CREEP AND SOIL SLIDES: FAVORABILITY VALUES OF GEOLOGICAL, VEGETATION AND RELIEF FACTORS AND A MULTINOMIAL LOGISTIC REGRESSION MODEL

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Abstract: On hillslopes where the regolith or soil cover is well developed, movement of the upper centimeters of regolith occurs downhill as a result of soil creep and surface sliding. These movements could be considered as a universal process occurring under all climate conditions. Normally, they represent slow processes and do not suppose a great risk, but involve a continuous transfer of edaphic material and consequently, they are implied in the soil redistribution of mountain areas.

Soil creep and surface sliding processes may produce some small landforms and steps over hillslopes. Spatial distribution of these morphologies could be related to the factors behind the processes and should be helpful in predicting sites where soil creep and soil sliding are more important. Following this idea, in a 250 Km2 mountain area located in the central Cantabrian Range, we have mapped 1324 points where creep-landforms and soil slides were identified.

Mapped morphologies were classified in four categories: 1) terracettes (295 points), 2) lobes and other microtopographic irregularities (617 points), 3) superficial soil slides (282 points) and 4) solifluction lobes and "festooned" slopes (130 points). Cartographic distribution was compared with several geological, geomorphological, vegetation and relief variables: 1) geological-geomorphologic variables like bedrock geology, surficial formations (lithologic and genetic classification), vegetation and presence/absence of rock area, and 2) relief variables like elevation, slope, aspect, curvature, relief index, flow accumulation and Compound Topographic Index (CTI).

The influence of each variable on creep-landform development was studied through a favorability analysis. Results obtained suggest how the presence of creep landforms is more frequent in slopes with calcareous lithologies and surficial deposits, and in those slopes with higher values of elevation, slope angles of approximately 25º-35º, high curvature values and relief index higher than 5 and lower than 9. Nevertheless, some relief variables, such as CTI or flow accumulation (which describes water movement and accumulation over the slope surface), do not appear to have a strong influence on the distribution of creep landforms.

Moreover, statistical modeling was accomplished with the aim of predicting areas where soil creep and surface sliding could be more probable. Firstly, we started by building a binomial logistic regression model, for which the dependent variable (spatial distribution of soil creep evidences) was considered as a dicotomic one (presence/absence). Model fitting was low, so after that, a multinomial logistic regression model was built, observing the initial four types of evidences. Multinomial model construction was based on adjusting four single independent binomial logistic equations, one for each type of evidence. The obtained four models fitted reasonably well. The model corresponding to microtopographic irregularities explains 73% of the data and excludes curvature, flow accumulation and local relief from the equation. Terracette model explains 85% of the spatial distribution of data and excludes presence/absence of rocky areas, flow accumulation and local relief from the model. Superficial soil sliding model shows a good fit, explaining 91% of data distribution; it excludes presence/absence of rocky areas, aspect, slope, curvature, flow accumulation, local relief and CTI from the model. Finally, gelifluction model considers geology, vegetation and elevation as independent variables and explains 84% of data distribution.

SLOPE INSTABILITY TRIGGERING DURING A RAINFALL EVENT IN ASTURIAS (SPAIN): AN EXAMPLE OF MEDIA IMPACT IN SCIENTIFIC STUDIES

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Abstract: This paper presents an example of using the press archives as a scientific data record. We have analyzed the information collected in the three major regional newspapers of Asturias (region of 10.590 km2 in the North of Spain) about slope instabilities related to an intensive episode of rains in June 2010.

It was possible to record 106 instabilities triggered between 10th and 29th of June 2010 based on news collected from digital newspaper archives. A spatial database was created in ArcGIS (v. 9.2). Relevant numeric and alphanumeric information of each event of instability was stored in a file with more than 60 fields.

Rainfall data from 87 weather stations of the Spanish Meteorological Agency (AEMET) have let constructing rainfall models for the Asturian territory by the deterministic method of spatial interpolation IDW (Inverse Distance Weighting). It has allowed recognizing the existence of two distinct precipitation events, from 7 to June 13 and from 14 to 17 June, with maximum values of 189.8 mm rainfall respectively on 9 and 123 mm on day 15.

A comparison of daily rainfall patterns and distribution of instabilities has allowed drawing some conclusions: although both episodes are felt throughout the region, rainfall data show that the first one mainly extended the north and northwest areas, while the second concerns mainly the South and Southeast of the region. This distribution of rainfall is reflected in the onset of instabilities, recording 46 of them in the north during the first rainfall event and 60 in the southern area during the second.

CONTRIBUTIONS BY PROFESSOR ANTONIO CENDRERO IN THE ANALYSIS OF LANDSLIDES AT MORRO DO BAÚ COMPLEX, SANTA CATARINA-BR

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Abstract: During November 21st to 25th, 2008, the Itajaí River low valley region, in the East side of Santa Catarina, registered 523.9 mm of rain, with a monthly total of 1,143 mm, representing 400% above average for the month of November. This exceptional pluvial episode, considered as the worst in a century in the region, and - according to the UNO - one of the most serious in the world, resulted in a large environmental catastrophe. Floods and landslides hit both urban and rural areas, resulting in 135 deaths, 21,269 homeless and 47,895 displaced people. The most affected area corresponded to the drainage headwaters, delimiting Morro do Baú, consisting of nine sub-basins, belonging to the left margin of Itajaí river, encompassing an area of 1,050 km2.

In order to analyse this event, the Government of Santa Catarina created a Scientific Technical Group (STG), which elaborated several projects, with the financial support of FAPESC (Fundação de Amparo a pesquisa de Santa Catarina – Santa Catarina Research Support Foundation). Teachers and students of the Geography course at UFSC took part in the project coordinated by Professor Edison Tomazzoli, for the analysis of hundreds of landslides at the Morro do Baú Complex as well as the elaboration of natural risks maps.

In face the need for furthering methodologies in the treatment of these issues, we relied on the competence and vast experience of Professor A. Cendrero, who together with his colleague, Professor Juan Remondo, shared my discipline at the Post Graduation Programme in Geography, teaching for two weeks during the month of April 2009, the course “Herramientas para la gestión sostenible de recursos y riesgos naturales” (Tools for sustainable management of resources and natural risks), and delivering several speeches for both the academic and professional community. At that time, a fieldwork was undertaken at Morro do Baú, where we had the opportunity to analyse landslides from wounds still exposed.

Several students were interested in elaborating researches on the theme as a result of the course, with the support of Professor Cendrero, who kindly returned twice to Florianópolis to guide students in executing projects, elaborating dissertations and thesis performed at the Morro do Baú complex.

We are thankful to the contributions by Professor Cendrero, an example of teacher, researcher and kindness.

PROGRADATION OF BEACH-DUNE SYSTEMS CONFINED BY DOCKS IN ESTUARY MOUTHS, CANTABRIAN SEA (N SPAIN)

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Abstract: The mouths of many Spanish estuaries have been modified over the last century to improve access to the ports that are located inside. The usual practice is the construction of breakwaters on one or both sides of the mouth with the purpose of improving the flow in the main channel, and thereby preventing the formation of bars in the main channel bottom. Another common situation outside the estuary mouth is the formation of spill over bars or bottom submerged deltas that add difficulty to navigation, especially during low tide or half tide, leading to shallower beds where waves break continuously. In spite of the dock extensions, in very few cases these measures have prevented the generation of such structures, bars have usually migrated to the new mouths or it has been necessary to deepen the navigation channel to 14 m (Avilés, Asturias). Furthermore, actions implemented in these environments favor the progradation of beach-dune systems, until stabilization occurs with respect to sea level and the confined space is unable to retain more sediment, thereby suffering from erosion in the dune fronts formed during this time period.

The pretense of this paper is to analyze the progradation rates of the beach-dune systems in several estuaries that drain into the Bay of Biscay and the subsequent erosion. For each estuary, the historical evolution of the dune field was studied using GIS software and geo-referenced documents, in particular historical cartography (from the eighteenth century), aerial photography and orthophotographs. The northward progradation trends observed in these estuaries correlate with dock construction.

This work confirms the evolution of prograding beach-dune systems following dock construction, with quick and voluminous accommodation in early decades that later stabilizes, causing low tabular dunes, vegetated within a decade. From this moment the erosive processes affect the dune fronts, resulting in subvertical slopes in the worst cases (Rodiles in Asturias) or focalized areas of erosion where longitudinal dunes are formed later in the interdune deflation corridors (San Vicente de la Barquera in Cantabria). In the Basque Country, most of the dune fields have been converted to urban uses making it difficult to study their evolution. Thus in some cases the development of the dune front could not be investigated during the erosion period, hence progradation rates have been calculated due to human intervention.

This methodology, exportable to other areas, promotes harbor and coastal political management and preservation of these environments, in order to facilitate the prediction of anthropic human effects.

GEOMORPHOLOGICAL MARKERS OF HOLOCENE TSUNAMIS IN THE ESTUARIES OF SOUTHWESTERN SPAIN: HUMAN IMPLICATIONS

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Abstract: This work reviews the geomorphological traces of prehistorical and historical tsunamis in the main estuaries of SW Spain. They include beach erosion, filling of intertidal channels, bioclastic layers, washover fans, reworked aeolian sheets or breacking of both spits and tombolos. Most of them were caused by the 218–209 BC and AD 1755 tsunamis, although the imprints of other local tsunamis have been also detected. Effects on human populations were severe and diverse, such as human losses, changes in coastal settlements and international borders, damages on port infraestructures or flooding of marsh, inhabited areas. New flood models reveal the plight of towns or biosphere reserves against future tsunamis.

VULNERABILITY OF COASTAL ZONES: DRIVING FORCES AND PATHWAYS FOR REDUCTION

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Abstract: Dramatic loss of life and economic assets in recent years underline the increasing importance of vulnerability reduction and disaster mitigation in coastal areas. As the concentration of people and assets in the coastal zone grow, addressing the key drivers of vulnerability – in particular, changing demographics, urban and economic development, environmental degradation, and governance dimensions – are crucial elements for developing successful adaptation and mitigation strategies. Since climate change will alter the frequency and magnitude of many natural hazards, it is essential to synthesise and capitalise on the knowledge gathered from past disasters and related research to elaborate best practice models. As current development pathways determine the vulnerability to extreme events of future coastal societies, above all realistic, feasible and frequent assessments are needed in order to adequately enhance coping capacities and adaptation measures.

Another critical issue is the context of knowledge production and application. Despite the concurrent increase of total asset exposure and in vulnerability research, few methodologies have been developed that integrate research findings, practical knowledge, and locally available data and expertise. The way in which knowledge production is traditionally designed and structured may partially explain why effective vulnerability assessments have been rarely implemented. In order to depict vulnerability to coastal hazards not only through the specialised scientific lens but to link research findings to societal actions, a shift from academic-driven, research-based knowledge production to co-designing context-sensitive knowledge is required. Based on engagement, communication and understanding between scientists and decision makers in policy and practice, a multiplicity of diverse knowledge producers, perspectives and methods may produce considerably more effective tools and applied measures to reduce coastal vulnerability.

After illustrating drivers and pressures of vulnerability, the paper frames the issue of increasing exposure of people and economic assets in coastal zones in the context of knowledge production. Challenges of disaster risk reduction are outlined and a vulnerability assessment of coastal communities in Cantabria, Spain, is presented. It is argued that in view of recent global environmental change processes coastal zones need to be a joint concerted focus of science, policy and operational practice to effectively strengthen resilience, mitigation and adaptation efforts.

DIFFERENTIATING BETWEEN GRAVITATIONAL AND TECTONIC FAULTS, THE CASE OF THE ZENZANO FAULT (IBERIAN CHAIN, N SPAIN)

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Abstract: Differentiating between tectonic and gravitational faults constitutes a major challenge for seismic hazard assessment with a still poorly developed scientific basis. Misinterpreting nontectonic faults as seismogenic tectonic structures (capable faults) may lead to significant seismic hazard overestimates with relevant economic and societal implications. This work illustrates through the case study of the Zenzano Fault (Cameros Range, Iberian Chain, Spain) how an integrated investigation including detailed geological-geomorphological mapping, trenching and geophysical surveys may help to elucidate whether an active surface fault corresponds to a tectonic structure (potentially seismogenic) or a gravitational failure (nonseismogenic). The N-dipping Zenzano normal fault has offset the back of a S-sloping cuesta generating a conspicuous scarp 1850 m long and 38 m high. This scarp has formed at the top of a laterally debuttressed erosional escarpment (cuesta front) around 500 m in local relief and with a subparallel orientation. The cuesta is underlain by a caprock of brittle Jurassic and Cretaceous carbonate and detrital formations and a tectonically thickened soluble and ductile evaporitic sequence (Late Triassic Keuper) associated with the Cameros Thrust. The antislope fault scarp has blocked some S-flowing consequent streams generating closed depressions (defeated streams) and hanging beheaded valleys in the hanging-wall and footwall, respectively. Two trenches and geophysical profiles (ERT, GPR) across the fault scarp have been investigated in the blocked drainages. The geometry of this active surface deformation strongly suggests that subsidence related to interstratal dissolution of evaporites plays a major role. The following information is explored as potential criteria to differentiate between tectonic and gravitation faults: (1) Geological and geomorphological context. (2) Characteristics of the deformation and morphometry of the fault scarp (i.e. aspect ratio). (3) Age of the deformation and slip rate. (4) Recurrence of faulting events and displacement per event.

NEOTECTONIC CONTROLS ON THE ORIGIN AND EVOLUTION OF KARSTIC POLJES IN THE SIERRA DE GRAZALEMA, RONDA MASSIF (BETIC RANGES, SW SPAIN)

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Abstract: The present work shows the determinant role played by neotectonics in the origin and later morphological evolution of karstic poljes located in the Sierra de Grazalema study area (southwestern Andalusia, Spain). The study zone is characterized by an extraordinary development, variety and spatial distribution of karstic forms, among which poljes represent the most emblematic and impressive landform. In the whole area 18 poljes were identified, some of them covering more than 2 km2 in area. A detailed geological, structural and geomorphological survey for each polje was carried out, as well as its morphological evolution was accurately reconstructed by using stepped corrosion surfaces as markers. In order to emphasize the major role of neotectonic controls in the evolution of the poljes, some significant multi-disciplinary issues were taken into account. In this sense, the stratigraphical and structural outline of the area proved to be useful for tracing the clear geological relationships between poljes and tectonic grabens along which they developed. In most cases, these exokarstic landforms show geometrical configurations which can be interpreted as minor pull-apart basins. Strike-slip tectonic lineaments and faults form the boundaries of these depressions, as well as some releasing and restraining bends which were identified on their margins. The statistical orientation and nature of the major families of fractures and faults of the zone was established in order to define which of them played a major structural control on polje generation and evolution. The stress field deduced from the bordering faults and lineaments of the poljes consist in a strike-slip regime under NNW-SSE compression and ENE-WSW extension, producing pull-apart basins and other grabens and semigrabens. This regime matches the present tectonic regional stress field for South Spain, deduced from earthquake focal mechanisms. A further comparison between the most relevant fault distribution and the present seismicity data of the zone was carried out. Results suggest a present tectonic activity for some of the major tectolineaments deduced from the morphostructural analysis.

As a conclusion, the 18 poljes of the zone are mostly considered as tectonic depressions generated in the Late Neogene (Pliocene times). During the Quaternary, they evolved as active tectonic structures where bottoms experienced several lowering episodes due to the combined effects of tectonic activity and climatic changes. Local base level lowering phases associated with tectonic episodes would have produced the stepping of solution surfaces, whose development would have taken place under favorable climatic conditions. Very likely other karstic processes, like the generation of swallow-holes or swallets, speleogenetic network development, doline distributions and orientations, etc., were also promoted and in some cases triggered by active tectonics.

GEOLOGICAL AND GEOPHYSICAL STUDY ON THE CAUSES OF THE ANDARA LAKE DRAINING (PICOS DE EUROPA, N SPAIN)

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Abstract: Located in a glacial valley, the Andara Lake constitutes the third mass of water by extension (19,000 m^2 aprox.) in the Picos de Europa Massif (NW Spain). Its sudden draining occurred in the second decade of the 20th century, during the development of underground Pb-Zn mining, between 1889 and 1929.

The present study was requested by the Autonomous Organism of National Parks (MAAM) with the purpose of: i) to localize the areas of water infiltration and ii) to establish the cause of the draining, specially its possible relation with the mining activity in the surroundings.

A series of electrical resistivity profiles was made in order to characterize the geometry and location of the infiltrations. The profiles were repeated at three different moments during the summer to evaluate the evolution of the infiltration. The resistivity profiles show two conductivity anomalies related to water presence in limestone. The anomalies can be correlated with previously exploited seams.

GEOLOGICAL AND GEOMORPHOLOGICAL ASPECTS RELATED TO THE 2012 SEISMIC SEQUENCE IN THE CENTRAL – SOUTHERN PO PLAIN (NORTHERN ITALY)

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Abstract: Since May 16 2012, a seismic sequence has affected the central-southern sector of the Po Plain (Northern Italy), in the Modena, Ferrara, Bologna provinces (Emilia–Romagna Region) and Mantova province. (Lombardia Region). A first main shock occurred on May 20 (Mw = 5.9; focal depth: 6,3 km; epicenter: few km north of Finale Emilia); a second main shock occurred on May 29 (Mw= 5.8; focal depth: 10,5 km; epicenter: about 12 km W of the first one). The seismic sequence has been characterized by other five quakes with Mw>5 and about 2.300 shocks till the end of july 2012. From a geological point of view, the subsurface of the epicentral area is characterized by several compressional northverging faulted folds of the Apennines (known as "Ferrara Folds") covered by marine and continental clastic deposits of the Po plain.

The geomorphological setting is characterized by a complex drainage and palaeo-drainage pattern of the rivers Po, Secchia, Panaro and Reno, strongly influenced by active tectonics of the Ferrara Folds, climate and human modifications. Some active fault-related folds are very close to the ground surface, deforming the topographic surface. The most relevant effect caused by the two stronger earthquakes was the 10-15 cm of uplift of the epicentral area, detected by the InSAR interferometry, corresponding to the hangingwall anticline of Ferrara Folds thrusts. At a detailed scale, more than five hundred geological/geomorphological effects were recorded over an area of about 700 km^2; they are mainly represented by widespread liquefaction phenomena and ground ruptures also accompanied by sand-boils. In some localities the bed of artificial channels did show uplifting, bulging and cracks, as the effect of the injection of sand under the bottom of the channel. Moreover, an extensive network of fractures and landslides was mapped on a road which runs on a bank of an artificial channel. The most evident and widespread effects induced by the first main shock occurred around the hamlet of San Carlo in which large ground cracks and widespread liquefaction affected both paved roads buildings and farmed land; this place is located on a fluvial ridge belonging to a Reno palaeoriver which was active till the end of XVIII century.

About the 80 % of the effects were induced by the May 20 main seism, while the 20% of the effects have been triggered by the May 29 second main shock. Many liquefaction phenomena triggered by the first main earthquake have been reactivated by the second one.

Liquefaction phenomena, characterized by the ejection of sand from ground fractures and wells, and ground ruptures, in several places characterized by a significant offset, appear to be concentrated along alignments which can be followed even for kilometers and driven by the local geomorphological evolution, dominated by a complex network of palaeorivers.

Other alignments roughly oriented E-W, identified in flat areas, cannot be explained with the local influence of palaeodrainages. Instead, their origin seems to be linked to the presence of E-W trending tectonic discontinuities that characterize the very shallow subsoil of the epicentral area. Also hydrogeological anomalies, such as strong water-table fluctuations, emission of hot water from ground cracks and water wells, have been recorded.

CAVES AS GEOMORPHOLOGICAL RECORDS: THE EXAMPLE OF EL PINDAL CAVE (CANTABRIAN COAST, N SPAIN)

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Abstract: This study focuses on the establishment of the spatial and temporal evolution of a cave system by using a multidisciplinary approach in the North of Spain. Geomorphologic mapping, structural, sedimentological analyses and absolute dating based on U-Th series and OSL were applied to El Pindal Cave. El Pindal cave is located at 24 m above sea level in the Cantabrian Coast (Asturias, NW Spain), in a karstic massif with a recharge area located in a marine terrace at 50-64 m above the present sea level.

The development of the cave was controlled by E-W trending faults that would have favoured the emplacement of phreatic conditions probably associated to the evolution of the Deva River. During the subsequent incision of the active level, several hanging alluvial levels of quartzitic composition were deposited in cave walls, documenting the entrance of alluvial deposits from the marine terrace reliefs located to the South (Pimiango terrace, 175-160m a.s.l.). Gravity processes (roof block collapse and subsidence evidence of cave floor), fluviokarstic processes (episodic flooding and detrital fluvial sedimentation) and chemical precipitation of speleothems covering gravity and fluvial deposits controlled the geomorphologic evolution of the cave for the last 230 ka.

U-Th dating, geomorphological study and annual laminae counting allowed the identification of five generations of speleothems: (1) Flowstones older than 230 ka; (2) Stalagmites from the Upper Pleistocene to the Middle Holocene (37 to 4 ka); (3) Stalagmites older than 7 ka; (4) Late Holocene stalagmites (from 3.3 ka to present) and (5) Stalagmites coeval or younger than 200 yr. Detrital levels dated by OSL techniques demonstrate the occurrence of cave flooding episodes at 120 ka, 75, 63 and 57 ka; one of these events is consistent with the geomorphic activity of an alluvial fan covering the karstic massif (61 ka).

GEOMORPHOLOGICAL FACTORS OF AN IMPENDING DISASTER (BALSA DEL SAPO, CAMPO DE DALÍAS, ALMERÍA)

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Abstract: The Campo de Dalías is the most intensively-occupied agricultural region of Europe and has been the source of economic development for the province of Almeria since the 1970s. A relevant factor of this emergent coastal platform is its endorheism, since geotectonic movements have created a kind of sink in the Pliocene deposits. The endorheic area runs along the foot of the Sierra de Gádor, an enormous mountain massif of Alpujarride units. The sierra is made up mainly of carbonate rocks dating from the Triassic, though it also contains some Miocene calcarenite and volcanic conglomerate. The transition from the Sierra de Gádor to the Campo de Dalías is via a series of spectacular alluvial fans, some of which reach 150 m in thickness, generated through the erosion of the massif and transport of the dismantled material via fifty or so ephemeral water courses ("ramblas") of variable size, which run off the southern face of the Sierra.

With 20,000 hectares under plastic, the aquifers of this area have had to supply a demand for water that greatly exceeds their recharge, over several decades. The consequence has been a continuous decline in piezometric levels and a persistent degradation in groundwater quality, as well as the incipient appearance of marine intrusion. All this has led to the competent authorities issuing a provisional declaration of the majority of the aquifer as overexploited.

The so-called Balsa del Sapo (Frog Pond) consists, in fact, of a number of lagoons, whose appearance has been relatively recent. The area began to flood about twenty years ago, when water began to appear in the bottoms of various clay pits excavated in the lowest-lying part of the endorrheic zone referred to above. The clays represent the fine fraction of the sediments transported by large flood events in the ramblas. They have been exploited for use as substratum in the plastic greenhouses of the Campo de Dalias. It is important to point out that the irrigation water used in these greenhouses comes largely from deep boreholes that tap the highly-transmissive Alpujarride limestone and dolomite. These deposits are isolated from the Pliocene calcarenite by a thick series of Pliocene marls that become increasingly sandy towards the surface. These calcarenites are barely 100m thick and the boreholes that exploit them began to reveal problems of water quality due to the fact that the lower horizons had an elevated saline content, possibly of connate origin. Abandonment of these wells and the return of irrigation water previously abstracted from the limestone, provoked a rise in the phreatic level. One consequence of this is the flooding of clay pits and the concomitant creation of wetlands which, over time, have acquired great ecological value. Nevertheless, the proximity of the agricultural exploitations and urban areas mean that the rise in hydraulic level represents a threat to these land uses, particularly during exceptionally wet years.

FLUVIAL BEDLOAD SEDIMENT TRANSPORT IN THE NARCEA RIVER BASIN (NW IBERIAN PENINSULA)

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Abstract: An analysis of bedload sediment transport was carried out in a fluvial system placed in NW Spain. Rivers from NW Spain drain from the Northern Cantabrian Range to the Bay of Biscay, dropping by around 2,000 m in a short path. Consequently, high-gradient streams typically develop and channel bed sediment normally falls in the range between gravel and cobble grain sizes. So, thus, coarse bedload transport has a great importance in these streams, governing fluvial behavior and controlling channel morphology. Bedload sediment transport also controls working life and maintenance of hydraulic works, like dams and channelizations, and it is involved in the management of flood risk.

Despite this, there are no many data, neither much information, on bedload sediment transport in these river systems. These research aims to determine quantitatively the main features of bedload transport in a river from the region, using two different approaches: a forward approach (tracer clasts and theoretical equations) and an inverse approach, based in analyzing morphological changes in channel planform. We selected Narcea river basin, which is quite representative from river catchments of NW Spain; within this basin, we studied three channels of different drainage orders. On the one hand, we chose Pigüeña (405 Km^2, drainage area) and Coto (210 Km^2) streams, where direct measurements of bedload transport (tagged stones: painted and with magnets inserted) were used and compared with the output of several theoretical equations (forward approach); on the other hand, we also studied the lowest Narcea main channel (1200 Km^2), where an analysis of aerial photographs was used to estimate bed-material sediment yields (inverse approach).Tracer experiences consisted in tagging several samples of fluvial clasts, coloring them with blue paint and also inserting magnets inside the clasts. Bedload transport rates in the range between 0.20 to 4.1 Kg/s were estimated for six flood episodes. When comparing these transport rates with the results given by several theoretical equations, the latter over predict several orders in magnitude.

Aerial photograph analysis was based in the comparison between historical aerial photographs (1957, 1985, 1994 and 2007) in order to determine surface changes experienced by the sediment storages. These surface changes were translated into volumetric ones and a sediment budget for the study reach was computed as the difference between sediment inputs into the reach and the changes in the sediment storages. We obtained a volume of 1,1x106 m^3 transferred throughout the study reach from 1957 to 2007; that means 24,000 m^3 per year.

Based on the tracer results, the analysis of threshold of motion and partial mobility made us suggest how finer sizes of sediment are preferentially transported during the more frequent flood events, while at the long term, both coarse and finer sizes are transported at a similar rate. Furthermore, we relate the strong over predictions of the theoretical equations to the possible limitations in the supply of sediment into the system, partially as a consequence of the structural arrangements within the bed sediment. Finally, results of the sediment budget show how important loads of sediment have been carried throughout the main channel of the basin. We think all these results converge and suggest how the long term bedload rates in the Narcea river basin result from the coupling between two different kind of transport events: low-intensity ones, associated to more frequent flood events, for which fine sediment is preferentially moved; and higher-intensity ones, associated to flood events with decadal return periods, where the transport of coarsest fractions of sediment is also important and morphological changes in the channel section are expected to undergo.

PROTECTED KARST AREAS AND SHOW CAVES IN SPAIN: GEOLOGICAL HERITAGE, CONSERVATION AND SOCIOECONOMIC IMPLICATIONS

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Abstract: Karst areas are important elements of the geological heritage and in many cases legal protection categories have been assigned due to their high environmental value. Besides their geomorphological diversity, spectacular landscape and ecological values it is necessary to consider the special characteristics of the endokarstic environment. In this work the geo-environmental aspects related with the karst use, protection and conservation in Spain are studied as well as the role of the karst in the context of the geological heritage and the socio-economy. Spain provides an interesting study case, existing about 150,000 km2 of karst terrains –which is more than 25% of the country surface- around 30,000 known caves, containing in many cases important natural, scientific, cultural and scenic values, and about 60 show caves that receive approximately 5 million visitors every year. In this work the legal categories protecting these areas, the presence of karst in geological heritage inventories, the management procedures and the role of karst and associated activities in general and local economies are discussed. The data are discussed in relation with the use, management and conservation of karst areas.

THE CONCEPTS OF GEOHERITAGE AND GEOTOURISM

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Abstract: There is a strong and indissoluble relation between the concepts of geoheritage and geotourism. In what concerns geoheritage we have already discussed the concept in previous papers and books and we cannot agree with those that defend equivalence between geoheritage and geological heritage or between geodiversity and geological diversity.

Geoheritage must be considered as defined by Rodrigues & Fonseca (2008, 2009a and posterior publications): "all the natural abiotic elements present in the Earth surface, emerged or submerged (representing the geodiversity of the Earth), that should be preserved due to its heritage value. So, geoheritage includes all types of abiotic heritage: from geology (fossils, minerals, structures, sediments, etc.), from geomorphology (landforms, correlative deposits, landscapes, etc.), from hydrology (sources, rivers, hydrographic basins, karst hydrology, etc.), from soil science (paleo-soils, "pedosites", etc.) or other types of heritage".

In what concerns geotourism we have also present our position in previous papers. Recently (Rodrigues, 2011) we discussed the main opinions about the concept of geotourism and present two definitions, one in strict sense and another in broad sense. In strict sense, geotourism can be considered as a tourism segment focused on the sustainable usufruct (by geotourists and local communities) of the geoheritage fruition. Geoheritage must be used here as defined in the last paragraph.

In broad sense, geotourism geotourism can be considered as a tourism segment mainly focused on the sustainable usufruct (by geotourists and local communities) of the geoheritage fruition, which can be added the cultural heritage (material and immaterial) of the areas. In this sense geoheritage is the driving force of the geotourism itineraries, but the cultural heritage it is also added to increase the value of the visited regions. This broader view of geotourism has the advantage of using cultural values to strengthen a sustainable model of promotion and development of areas based in its geoheritage. Luckily this is the case of many Iberian rural regions.

However, nowadays there are some earth scientists that do a lot of efforts to connect geotourism only with geoparks, as if one can only do or implement geotourism inside geoparks. We can understand that type of concern (but not of short vision) when it comes from geopark managers. But that position cannot be sustainable when comes from researchers, as some connected to ProGEO, once the concept of geotourism precedes that of geopark. That does not mean, of course, that geoparks are excellent areas to promote geotourism practices.

THE ROLE OF GEOMORPHOLOGY IN THE MANAGEMENT OF THE DOLOMITES (UNESCO WORLD HERITAGE SITE)

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Abstract: The Dolomites have been included in the World Heritage List because of their exceptional beauty and unique landscape (criterion VII), together with their scientific importance from the geological and geomorphological point of view (criterion VIII). The inclusion of these mountains in the List as a site "with outstanding universal value" is therefore an extraordinary form of recognition, but also implies a strong commitment and responsibility for the safeguarding and sustainable development of this region.

In order to acquire correct geomorphological understanding of these mountains, with reference to their inclusion in the UNESCO World Heritage List, an original interpretation has been introduced, that is, "geomorphodiversity" (Panizza, 2009), defined as: "the critical and specific assessment of the geomorphological features of a territory, by comparing them in a way that is both extrinsic (with other territories) and intrinsic (with the territory itself). It takes into account the level of their scientific quality, the scale of investigation and the purpose of the research".

When considered as a whole, these mountains offer exceptional complexity of morphostructural and morphoclimatic landforms, even in the most minute details. In fact the aggregation of all these landforms, whether they be relict, recent or active, has produced with time a geoheritage, that can be considered as a high-altitude field laboratory for research and development of geomorphological theories and understanding.

As for the management of the Dolomites, regarding in particular Geomorphology, a conceptual path is suggested and illustrated, following the phases of knowledge, communication, awareness, protection and appraisal (Panizza & Piacente, 2003).

This kind of management must imply the various relationships between "Man" and "Geomorphology", in terms of geomorphological heritage, geomorphological hazard, geomorphological impact, geomorphological risk, geomorphological sensitivity and geomorphological dis-equilibrium. Some examples are illustrated.

FLOOD RISK MANAGEMENT IN NORTH SPAIN: TOWARDS MORE SUSTAINABLE PLANNING POLICIES IN FLOODPLAINS

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Abstract: The northern slope of Cordillera Cantábrica (Spain) is drained by 25 small basins (up to 4,900 km2) with relatively steep channels and narrow flood plains. The recent economic growth of this area has given rise to the urban development of flood prone areas, which has significantly increased the exposure to floods and risk levels in this region, especially during the second half of the 20th century.

Up until January 2008, authorisation of new urban developments on flood-prone terrains only required a defence project for a design discharge of a given return period. This approach has failed in reducing flood risk because: (1) defence works were not always designed with the appropriate return period and sometimes they were not carried out; (2) channel corrections promoted secondary geomorphic changes, mainly bed incision and aggradation processes; and (3) these geomorphic changes altered channel sections that modified the design hydraulic capacity (e.g., riverbed cogging), often resulting in flood hazard increase. We quantify these issues in several rivers of this region and argue that flood risk management should be improved.

In 2008 was approved "Real Decreto 9/2008", a modification of the Spanish Water Law inspired by the European Flood Directive (Directive 2007/60/EC) that introduced the concept of "zona de flujo preferente", i.e., "main floodway". This main floodway, defined in terms of hydrologic, hydraulic, geomorphic and historic criteria, includes those sectors of flood plains where high depth and velocity values are expected during a 100-year return period discharge, as well as significantly large erosion and bedload transport rates. According to this legislation, new urban developments are forbidden within the main floodway area. The purpose of this restriction is twofold: to avoid a new increase in flood risk levels and to preserve the natural functions of alluvial plains during floods, which also contributes to reduce flood hazard and risk.

We argue that the main floodway constitutes a very effective tool for urban planning in flood prone areas, particularly on the northern slope of Cordillera Cantábrica. The integration of this restriction area into urban planning is a more sustainable approach to risk management, since it focuses on reducing vulnerability and exposure instead of hazard, thus preserving the natural functions of fluvial systems and preventing geomorphic alterations. Municipalities play a major role in this new approach because they are in charge of urban planning at the local level. Finally, we discuss the outcome of this approach in several municipalities of North Spain that have incorporated into their Planning Policies building-free «fluvial corridors» based on the main floodway concept.

THE LANDSCAPE AND GEOMORPHOLOGY IN THE PLANNING AND MANAGEMENT OF NATURAL PARKS. APPLICATIONS IN THE LAS BATUECAS-SIERRA DE FRANCIA AND QUILAMAS NATURAL PARKS, SW SALAMANCA (SPAIN)

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Abstract: Currently the landscape is of importance in the overall set of environmental aspects and is a determinant factor in the quality of life of the population, as reflected in environmental legislation (European Landscape Agreement 2000, INSPIRE Directive 2010),developing tools for its protection, management and planning through studies of strategic assessment and the evaluation of environmental impacts, which require and/or demand the compilation of maps, catalogues and reports about the landscape.

This study has a double aim, taking into account on one hand the presence and distribution of the components of the landscape –the total landscape- which identifies the landscape with the environment on the basis of the thematic components of the landscape (relief, vegetation, hydrology…) and the characterization of its attributes (orientations, slopes…), and on the other the visual landscape, where the natural surroundings are evaluated on the basis of aesthetic or perceptual criteria.

Regarding methodology, in the first part of the work we perform an indirect landscape analysis of the Las Batuecas-Sierra de Francia and the Quilamas Natural Parks, consisting of a cartographic procedure implemented with GIS techniques that defines their landscape units from homogeneous units (geomorphology and lithology) according to the structure, functionality and visual characteristics of the natural components forming them, which together with the vegetation allowed us to obtained a mapping of the landscape units. The indirect landscape analysis generates two cartographies: a map of the landscape quality, in that they stand out sectors of crests and valleys as being of very high landscape quality (the crests of the Sierra de Francia, the valley of the Quilamas river, the valley of Las Batuecas and the Sierra de la Canchera) and of high landscape quality: the sectors surrounding the above ones (Pinedas, Dios le Guarde, Hondura, Pastores and Guadapero). Then, we elaborated the cartography of the landscape fragility, which showed the response capacity of the natural environment or vulnerability to the different uses of the territory owing to human activities, that revealed a very high response capacity of the natural environment, or vulnerability, in zones of very high quality, corresponding to domains of sierra summits and crests (the Sierra de Francia, Quilamas, the Sierra de la Alberca and the Sierra de Herguijuela de la Sierra) and high fragility for the tops of hillsides: Molinillo, the south of Colmenar de Montemayor, the Pinedas sector and the southern flank of the Guadapero synclinal.

In a second phase we performed a direct landscape analysis, describing the different landscape units on the basis of their visual characteristics by direct observation. We completed the identification of the different components of the landscape with 3D modelling using a Digital Terrain Model, assessing the singular areas and their natural elements.

From the Quality and Landscape Fragility maps (indirect methods), and taking into account the maps of Landscape Units (direct methods), we obtained the cartography of the Capacity for Perceptual Absorption, which measures the degree of anthropic intervention and the need for conservation. The results obtained revealed that the Las Batuecas-Sierra de Francia and Quilamas Natural Parks have high and very high absorption capacities, or minimum conservation, in the surroundings of several localities dispersed over the piedmont, such as

Valdecarpinteros, Morasverdes, the south of Aldehuela de yeltes and the north of El Maillo, at the foot of the talus of the river escarpment that runs from El Maillo to Aldehuela de Yeltes, at the base of the SE face of the Sierra de Tamames, and in the inner sectors of the valley of Quilamas and the valley of Las Batuecas.

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