

## Mud-breccia clasts and sediments as nucleation sites for hydrocarbon-derived ferromanganese nodules in carbonate-mud mounds from the Gulf of Cadiz

F.J. GONZÁLEZ<sup>1</sup>, L. SOMOZA<sup>1</sup>, R. LUNAR<sup>2</sup>,  
J. MARTÍNEZ-FRÍAS<sup>3</sup>, J.A. MARTÍN RUBÍ<sup>1</sup>, T. TORRES<sup>4</sup>,  
J.E. ORTIZ<sup>4</sup> AND V. DÍAZ DEL RÍO<sup>5</sup>

<sup>1</sup>Geological Survey of Spain (IGME). Madrid, Spain  
(fj.gonzalez@igme.es)

<sup>2</sup>Dpto de Cristalografía y Mineralogía (UCM). Madrid, Spain

<sup>3</sup>Centro de Astrobiología (CSIC/INTA). Madrid, Spain

<sup>4</sup>Laboratorio de Estratigrafía Biomolecular (ETSIM/UPM).  
Madrid, Spain

<sup>5</sup>Centro Oceanográfico de Málaga (IEO). Málaga, Spain

During the Anastasya-01 cruise (TASYO project), extensive nodule fields were discovered and sampled for the first time at water depths ranging from 850 to 1000 m, associated with hydrocarbon-derived carbonate chimneys and crusts in the Guadalquivir Diapiric Ridge area (eastern Central Atlantic) [1]. Nodules show a wide range of sizes and predominantly tabular shapes. They are formed of multiple millimetre-thick layers of Fe and Mn oxides surrounding the nucleus composed of Early-Middle Miocene plastic marls and mud-breccia sediment, which were derived from underlying units by fluid venting. Fe-Mn layers and carbonated cores display the same microtextural features, composed by zoned rhombohedral crystals (authigenic Fe-Mn oxides in layers, and siderite to rhodochrosite in the nuclei) surrounded by detrital grains (silicates) and framboidal associations (fresh pyrite or totally pseudomorphised by goethite). The center of the rhombohedral crystals are enriched in manganese and their exterior edges are iron enriched for both, Fe-Mn oxides and Fe-Mn carbonates. Nodules show a high mean abundance of Fe (38.6%) moderate Mn (6.0%), and low contents of trace metals and REEs compared to the average content of deep-seabed polymetallic nodules [2]. The studied nodules hold in their oxide layers and cores hydrocarbons (n-alkanes), with a first concentration maximum at n-C<sub>18</sub>, derived from marine bacterial activity, also with presence of aromatic hydrocarbons as phenanthrene, characteristic of mature petroleum. Bacteria-mediated oxidation of hydrocarbons through Mn<sup>4+</sup> and Fe<sup>3+</sup> reduction, could be related to the precipitation of Fe-Mn carbonates and sulphides, forming siderite-rhodochrosite concretions below the redox boundary within the sediment, that later were transformed into ferromanganese-oxide nodules by exhumation and exposition to the sea bottom oxidising waters.

### References

- [1] González, F. J., Somoza, L., Lunar, R., Martínez-Frías, J., Martín Rubí, J. A., and Díaz del Río, V. (2006), *Boletín Geológico y Minero* **117**, 491- 497.  
[2] Baturin, G.N. (1988), The geochemistry of manganese and manganese nodules in the ocean. In: D. Riedel Publ. Co. 342 pp.

## A noble gas approach to fluid origin in mesothermal gold deposits, Otago and Alpine Schists, New Zealand

N.R.J. GOODWIN<sup>1</sup>, C.J. BALLENTINE<sup>1</sup>, R. BURGESS<sup>1</sup>,  
D.CRAW<sup>2</sup>, H. SUMINO<sup>1</sup> AND D.A.H. TEAGLE<sup>3</sup>

<sup>1</sup>SEAES, The University of Manchester, UK

(nicholas.r.goodwin@postgrad.manchester.ac.uk)

<sup>2</sup>Geology Department, University of Otago, Dunedin, NZ

<sup>3</sup>NOC, University of Southampton, UK

Mesothermal gold deposits are economically significant on a global scale yet the origins of both the gold and the mineralizing fluids remain poorly understood. The relative contribution and mixing of meteoric, magmatic and metamorphic derived fluids is not well known and may involve complex fluid evolution, mixing and unmixing.

Noble gases are ideal tracers of fluid origin in crustal materials due to their chemical inertness and low abundance. The atmosphere, mantle and crust have unique noble gas isotope fingerprints that are resolvable, as is the relative contribution of these components as the fluid evolves. Magmatic fluids are identifiable by primordial <sup>3</sup>He and crustal fluids by radiogenic isotopes, such as <sup>4</sup>He and <sup>40</sup>Ar. The presence of a diluted dissolved atmospheric signature may indicate the mixing of meteoric and metamorphic fluids and the degree of isotopic or elemental fractionation can identify unmixing processes such as boiling.

We focus on two mesothermal gold systems in New Zealand. These are Mesozoic economic deposits hosted in the Otago Schists and Pliocene-recent gold bearing quartz veins in the Southern Alps (Alpine Schist). The latter study provides a suite of quartz vein samples from a variety of crustal depths to the brittle-ductile transition to investigate meteoric fluid penetration versus metamorphic fluid buoyancy in the Southern Alps. The absence of any igneous bodies simplifies potential fluid sources. Initial results from Southern Alps samples confirm the predicted absence of magmatic fluids, with no resolvable magmatic <sup>3</sup>He component. Crustal radiogenic (e.g. <sup>4</sup>He and <sup>40</sup>Ar) and meteoric water-derived noble gases (e.g. <sup>20</sup>Ne and <sup>36</sup>Ar) are readily resolved and will enable us to identify fluid source and mixing process.