

New conventional oil and gas discoveries

Exploration expenditure rose sharply in 2013, as in the previous year. The overall results for 2014 are likely to show more modest growth at around 5%. In ten years, exploration budgets have increased fivefold, which has led to some major discoveries; but since 2010, the volumes discovered have fallen every year despite the continuing increase in spending. In 2013, 17 billion barrels of oil equivalent (Gboe) were discovered. This is less than both the amount for the previous year and the ten-year average. The initial estimates for 2014 suggest a stabilization of volumes discovered at the same level as 2013. The continuing decline in offshore discoveries in Brazil and East Africa, where operators have cut back on their exploration programmes, appears to have been partly offset by the increase in border areas, such as the presalt reservoirs in West Africa and the Russian Arctic.

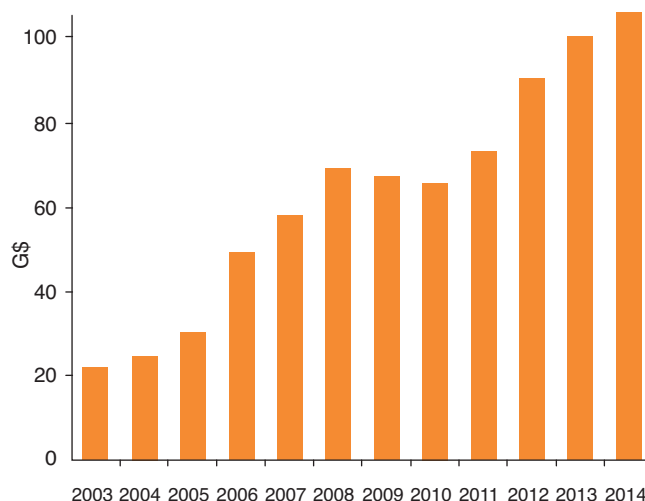
This note concerns discoveries made using conventional exploration methods. Hydrocarbon deposits in bedrock and tight formations, which are behind the strong growth of production in the United States, are not covered. Discoveries made in these fields are not usually announced by the companies, except on initial exploration in a new province. Once the field is in operation, the reserves are constantly reassessed and increase with each new well, but this does not constitute a discovery in the strict sense of the term. For instance, reserves of tight oil increased by 2.7 billion barrels (Gbbbl) in the US in 2013 (latest available data) and now account for nearly 30% of proven reserves.

Continued rise in exploration expenditure

Spending on exploration and assessment increased by 11% in 2013, following the 24% increase in 2012. In 2014, growth is likely to have continued at the more modest rate of around 5% and reach a new record at \$106 billion. Spending on exploration has increased by 60% since 2010 and multiplied five-fold since 2003 (Fig. 1a).

These significant exploration activities have led to major discoveries since 2006, particularly in the Brazilian presalt reservoir and offshore in East Africa off Mozambique and Tanzania. But the volumes discovered in 2013 should only account for 17 Gboe compared with 28 Gboe in 2012, *i.e.*

Fig. 1a – Trends in spending on exploration



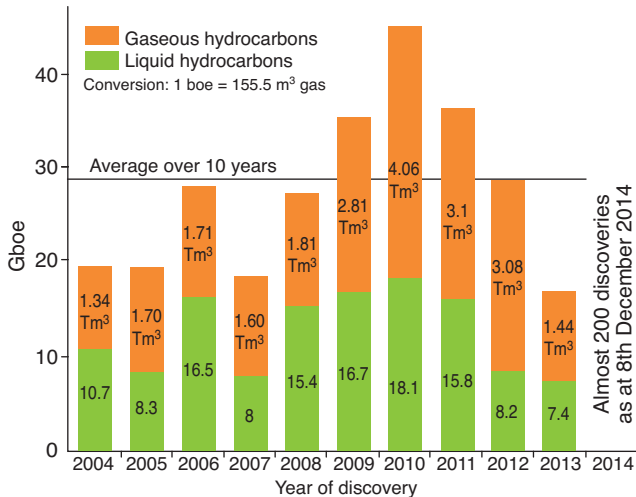
Source: IFPEN

only half of the average for the previous five years and 40% below the average for the whole decade (Fig. 1b). However it should be noted that this estimate is sure to be revised upwards, since all the exact volumes are not yet known. After reaching a peak in 2010, the volumes discovered have fallen every year, which can be explained by reduced exploration in the areas that have been most prolific in recent years (the Santos basin in Brazil and the Rovuma basin in Mozambique and Tanzania), and where

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operators are refocusing their efforts on assessment and development of earlier discoveries. Other basins that have proved promising have not yet taken over in terms of volumes discovered, but should increase their output in the coming years (presalt in West Africa, East African rift, Arctic, etc.), as they began to do in 2014.

Fig. 1b – Estimated discoveries between 2004 and 2014



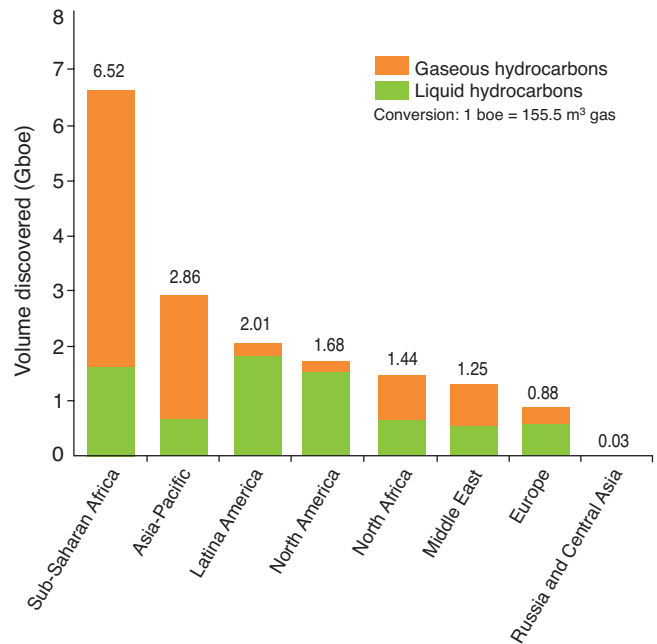
Source: IFPEN based on WoodMackenzie

Reminder of the main discoveries of 2013

Around 17 Gboe were discovered in 2013 – less than in the previous three years and 40% below the ten-year average. As in 2012, Sub-Saharan Africa is the regional leader, even though it only accounts for 35% of the volumes discovered compared with two-thirds the previous year. The Rovuma basin offshore area, off Mozambique and Tanzania, has remained the most prolific area with nearly a quarter of the reserves discovered compared with nearly half in 2012. Considerable volumes have also been discovered in Angola and Nigeria. The massive Lontra discovery by Cobalt International, estimated at around 740 Mboe of gas and condensates, confirmed the potential of the Angolan presalt reservoir. It was followed by an oil discovery representing a volume of between 150 and 300 million barrels (Mbbbl). In Nigeria, the Ogo discovery is the fourth biggest of the year, with approximately 750 Mboe and associated gas (Fig. 2).

Exploration activities have slowed down in Brazil, where less drilling has taken place. However, the success rate has improved to reach 70%, putting Brazilian offshore in second place behind Mozambique in terms of volumes discovered per country. While the share of gas is still preponderant in the discoveries, it has fallen to 56% of

Fig. 2 - Volumes discovered by geographic region in 2013



Source: IFPEN based on WoodMackenzie

the total compared with 70% in 2012. This is the result of the drop in discoveries off the coast of Mozambique and Tanzania.

In North America, exploration in the Gulf of Mexico yielded one of the best results since 2003, with over one Gboe discovered. Two major discoveries were also announced in Canada, off the coasts of Newfoundland and Labrador, where Statoil confirmed the existence of a new oil province. The volumes already discovered are between 400 and 800 Mboe.

The discovery at Salamat, in Egypt, is the year's biggest outside Mozambique. It was also the most costly (\$360 million) due to particularly difficult conditions, with a deep reservoir and high pressures and temperatures. This discovery could boost interest in exploration in the Nile delta, which has considerable potential. But Egypt must give companies better contractual conditions, since the regulated gas prices are currently too low with regard to the high development costs.

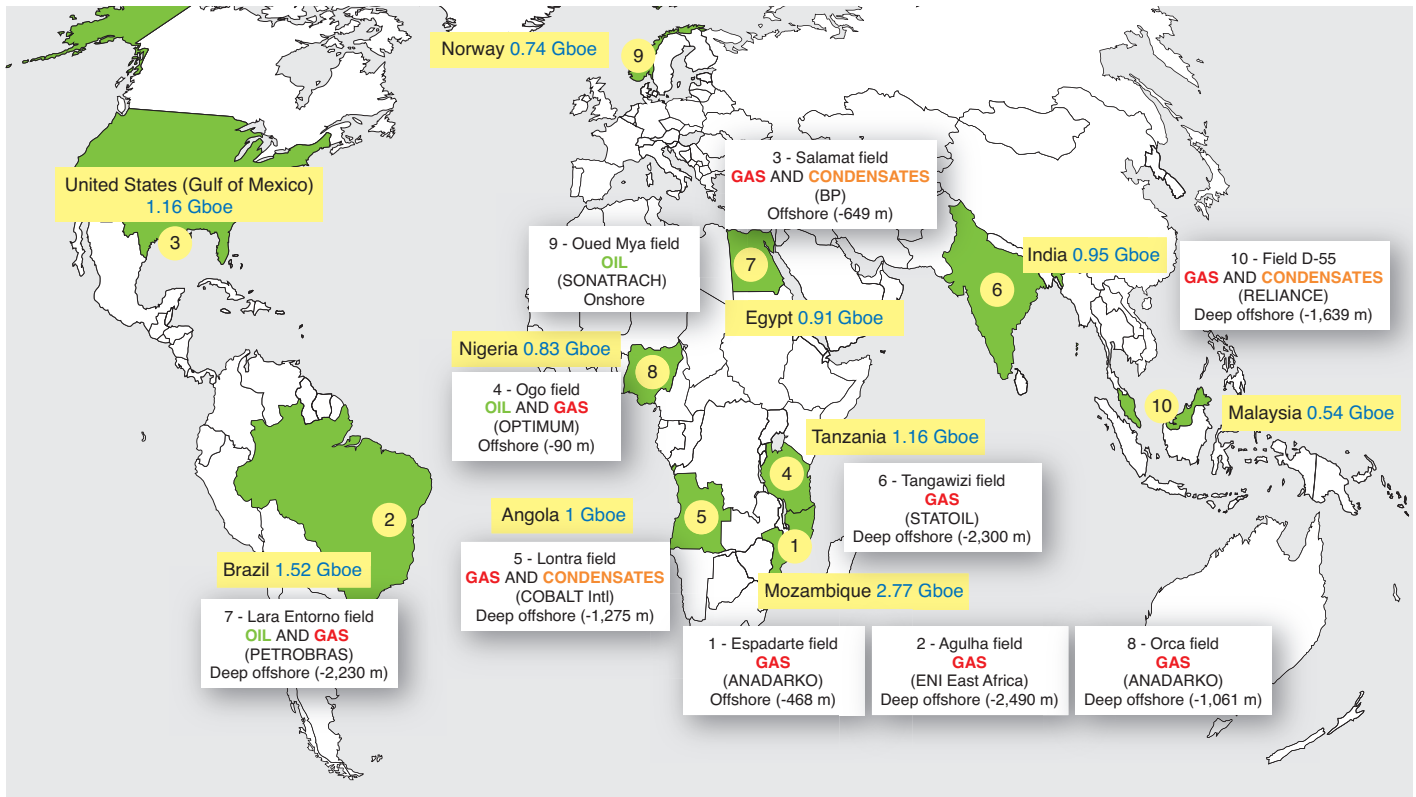
In Algeria, Sonatrach has announced the huge discovery at Hassi Touimet, where the resources in place are estimated at 1.3 Gboe in a low permeability reservoir.

In India, 492 Mboe of gas and condensates were discovered by Reliance in the Krishna-Godavari basin.

Notable successes have also been achieved in Kazakhstan (Zhambyl discovery), the Bonaparte basin in Australia and in the Barents Sea with the Wisting Central discovery (200-500 Mboe) (Fig. 3 and Tab. 1).

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Fig. 3 - Top 10 countries in terms of volumes discovered in 2013 and the new border basins



Source: IFPEN based on WoodMackenzie

Table 1

The 10 most significant discoveries of 2013

	Country	Basin	Field	Oil/Condensates (Mbbl)	Gas (Gm ³)	Total (Mboe)
1	Mozambique	Rovuma	Espadarte	25	204	1,249
2	Mozambique	Rovuma	Agulha	42	137	864
3	Egypt	Nile Delta	Salamat	22	124	766
4	Nigeria	Keta-Togo-Benin	Ogo	300	72	732
5	Angola	Kwanza	Lontra	300	71	726
6	Tanzania	Coastal basin	Tangawizi	0	99	594
7	Brazil	Santos	Lara Entorno	547	6	583
8	Mozambique	Rovuma	Orca	11	92	563
9	Algeria	Oued Mya	Hassi Touimet	500	0	500
10	India	Krishna-Godavari	D-55	140	57	482

Source: WoodMackenzie, IFPEN conversions for m³, boe

As in previous years, 2013 discoveries are dominated by deep offshore, with two thirds of the volumes discovered at water depths of over 400 m. This proportion has doubled in 10 years (Fig. 4).

Main trends for 2014

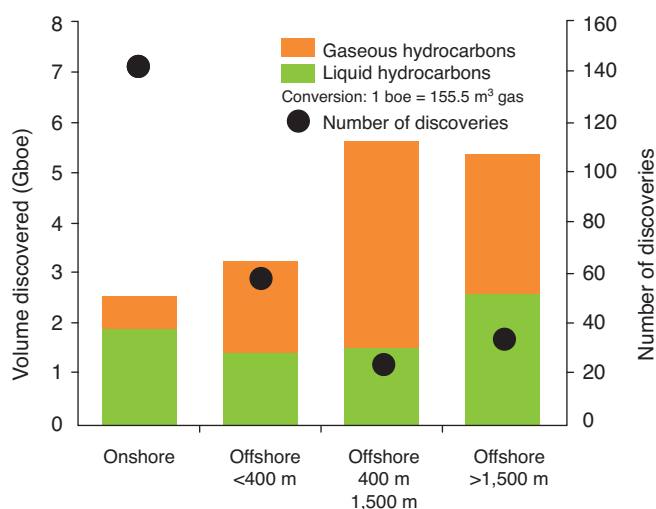
As at 8th December 2014, more than 200 discoveries had been announced in 48 countries. Although little is

known about the exact volumes discovered, they are likely to be similar to those recorded in 2013. While Brazilian presalt and East African offshore have been less prolific this year — since the operators have focused their efforts on assessment and development of the resources discovered — new provinces (West African presalt, East African rift and Kara Sea basins) have produced significant discoveries.

The year's biggest discovery was made by ExxonMobil, in partnership with Rosneft, whose first drilling in the

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Fig. 4 – Discovery types in 2013



Source: IFPEN based on WoodMackenzie

Kara Sea revealed the Pobeda (Victory) field, estimated to contain 130 Mbbl of oil and 499 Gm³ of technically recoverable gas. According to Rosneft, this Kara Sea region could hold 87 Gbbl of oil and the whole area could contain reserves equivalent to those of Saudi Arabia. But the international sanctions hitting Russia, which forced ExxonMobil to close the well immediately after the announcement of the discovery, are likely to delay exploration of the Russian Arctic.

As in previous years, Sub-Saharan Africa gained the lion's share with six of the year's ten main discoveries. West Africa presalt confirms its potential with discoveries off Angola, Congo-Brazzaville and Gabon. In Angola, Cobalt International has made two significant presalt oil discoveries: Orca (400-700 Mbbl) and Bicular (150-300 Mbbl). Since 2012, the independent American company has dis-

covered between 1.1 and 2 Gbbl in this area and estimates the volume remaining to be discovered under its two Angolan licences at over 25 Gbbl. The decision to invest in development of the Cameia field, discovered by Cobalt in 2012, is expected in the first quarter of 2015. In Congo-Brazzaville, the Nene Marine 3 discovery (ENI) brings the estimated volumes in place in the field to 1.2 Gbbl of oil. It was followed by discovery of the Minsala Marine field, 12 km away, which contains an estimated volume of one Gboe, including 80% oil. ENI has also discovered 500 Mboe of gas and condensates in the Gabon presalt reservoir. The Italian firm estimates that it has found around 4 Gboe since 2013 in the Congo and Gabon. These discoveries are located in fairly shallow waters close to existing infrastructures, which should allow fast development. In Senegal, Cairn Energy has discovered between 250 Mbbl (P90) and 2.5 Gbbl (P10) of oil in the Cretaceous sandstones, at a water depth of 1,400 m. In East Africa, Tanzania is well placed with five discoveries accounting for between 150 and 200 Gm³ of gas in situ. Kenya stands out with 13 discoveries, including 11 onshore by Tullow. The independent Anglo-Irish company estimates that it has already discovered 600 Mbbl of oil in the North-West of the country and hopes to soon exceed a billion by continuing exploration of the area. In addition, off the coast of Mombasa, BG Group has made the first East African offshore oil discovery (Tab. 2).

Other noteworthy facts:

- in Brazil, the Canadian company Alvo Petro has discovered 57 Mbbl of oil and 107 Gm³ of gas onshore in the Recôncavo basin (State of Bahia);
- in the Barents Sea, the Alta discovery by Lundin Petroleum (125-400 Mboe) could, if the initial estimates are confirmed, be one of the biggest of the century in Norway;

Table 2

Main announcements in 2014

	Country	Basin	Field/Well	Oil (Mbbl)	Gas (Gm ³)	Total (Mboe)
1	Russia	Kara Sea	Victory	130	499	3,125
2	Senegal	Senegal basin	Sangomar Deep	250-2,500		250-2,500
3	Congo-Brazzaville	Congo basin	Minsala	800	33	1,000
4	Angola	Kwanza	Orca	400-700		400-700
5	Brazil	Recôncavo		57	107	699
6	Congo-Brazzaville	Congo basin	Nene Marine	600	10	660
7	Tanzania	Rovuma			57-85	342-510
8	Gabon	Gabon basin	Nyonie Deep	500		500
9	Norway	Barents Sea	Alta	85-310	7-15	125-400
10	Australia	Canning	Phoenix	300		300
11	Angola	Lower Congo	Ochigufu	300		300
12	Ecuador	Oriente	Oglan	300		300

Source: IFPEN

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- outside the Congo and Gabon, ENI made two big oil discoveries (300 Mbbl of oil each), in Angola and Ecuador, as well as a significant gas discovery of 37 Gm³ (220 Mboe) in Indonesia;
- Apache's discovery at Phoenix, in the Canning basin, is one of the biggest in Australia in recent years. It is estimated at 300 Mbbl of oil;
- many discoveries have been announced in Australia, Colombia and China, but the volumes are generally either unknown or quite low;
- as in the previous two years, Norway is in the lead in terms of announced discoveries; with 27 successes listed, but the volumes are only known for 12 of them, for a total of 782 Mboe. The second biggest discovery, after Alta as mentioned above, is attributed to VNG Norge in the Norwegian Sea (170 Moe, mainly oil). In addition, Wintershall has made a discovery in the North Sea, for which the volumes have not been announced but which has made it possible to assess the reserves of the Skarfjell field, now estimated at between 120 and 230 Mboe (Fig. 5).

Fig. 5 – Number of discoveries announced in 2014 (on 8th December) per country



The size of the circles is proportional to the number of announcements listed

Source: IFPEN

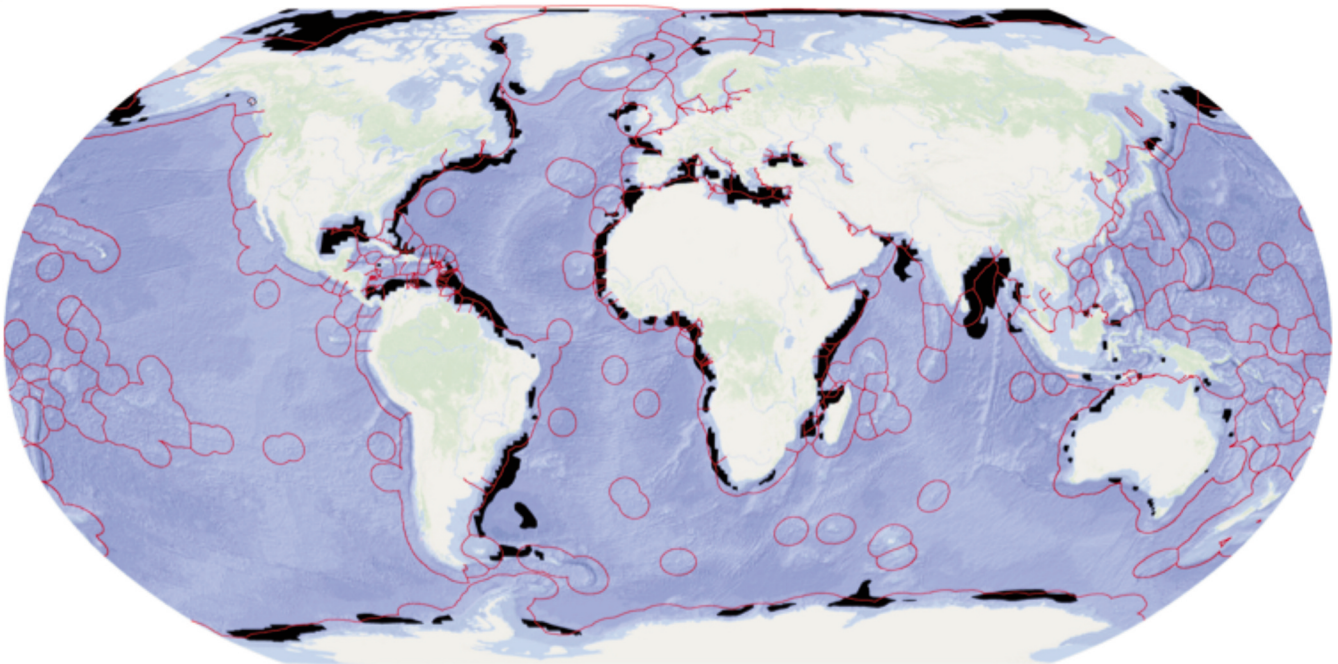
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Hydrocarbons at water depths of over 2,000 m

For many years now, the main discoveries of hydrocarbons have been in increasingly deep waters. The Perdido production platform (Gulf of Mexico, Shell) produces oil from water depths of almost 2,500 m and the future Stones installations, still in the Gulf of Mexico, will produce from water depths of 2,900 m. The hydrocarbon potential of deep and ultra-deep offshore is therefore proven. Is there a bathymetric limit beyond which hydrocarbons will no longer be found?

Hydrocarbon formation entails specific geological conditions (the "petroleum system" referred to by geologists), which do not depend directly on current water depth, but rather the geological context. Aside from the particular features of each region, the oil potential of the continental margins is governed by two key geological factors: the presence of a bedrock con-

taining organic matter, and a sufficient temperature in the sediments to have generated liquid hydrocarbons (70/80°C) then gaseous hydrocarbons (>100°C). This is the factor that will limit the oil potential in the deepest parts of the oceans. Gradually, as we move away from continents whose erosion provides most sediment, the sediment thickness decreases to become very low (<500 m). Because of low geothermal flow in the abyssal zones, hydrocarbon genesis only begins if the source rock is buried at a depth of over 2,500 m. In zones where the total sediment thickness is less than this value, the oil and gas potential is very low. The figure below shows (in black) the zones with both a water depth of over 2,000 m and a sediment thickness of over 2,500 m. There is therefore still a high potential to be explored at water depths of between 2,000 and 4,000 m, but beyond 4,000 m the potential becomes extremely low.



Distribution of zones with a hydrocarbon potential in water depths of over 2,000 m (in black). In red, the limits of the Exclusive Economic Zones (EEZ)

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Who do these hydrocarbons belong to?

If the deposit is located in an internationally recognized Exclusive Economic Zone, the country's mining rights apply. This area extends over 200 miles from the baselines (generally the coastline) of the country concerned and may be extended up to 350 miles after approval of the extension application by the UN. The maritime areas located beyond the States' national jurisdiction form "the Area". Opening up a bold path between sovereign freedom and the exclusive rights of Sea States, the United Nations Convention on the Law of the Sea 1982 established joint ownership of the Area's mineral resources, considering them as the common heritage of human-

kind. Their administration is the responsibility of the International Seabed Authority, which manages over 150 million km², *i.e.* over half of the earth's surface! The aim is for these activities to benefit the whole of humankind, with special attention paid to the interests of developing States. The International Seabed Authority manages the exploitation of mineral resources in the Area, grants exploration permits, and in the case of discovery and production, collects royalties in the name of humankind. The coastal State has the benefit of five years' exploitation free of charge. From the sixth year it has to pay 1% of the production value. The contribution rate then increases by 1% per year until the twelfth year, at which point it is capped at 7%.

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