GEOMINAS

VOLUMEN 49, N° 86
DICIEMBRE 2021

UNIVERSIDAD DE ORIENTE
VENEZUELA

ESCUELA DE CIENCIAS DE LA TIERRA

ISSN: 0016-7975

Depósito legal: pp196403BO252

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GEOMINAS

ESCUELA DE CIENCIAS DE LA TIERRA
UNIVERSIDAD DE ORIENTE
VENEZUELA

BOLETÍN N° 86 DICIEMBRE 2021

Direcciones:
Boletín GEOMINAS. Escuela de Ciencias de la Tierra de la Universidad de Oriente. Campo universitario La Sabanita. Ciudad Bolívar. Edo Bolívar. Venezuela.
http://www.revistageominas.com

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PUBLICACIÓN ARBITRADA

Registrada en:

EBSCO
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ISSN: 016-7975
Depósito Legal: pp 196403BO252

Edición financiada por:

INTERROCK When Integration is the Answer

FUNDA GEOMINAS Fundación de Amigos y Egresados de la Escuela de Geología y Minas

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Volumen 49, N° 86, diciembre 2021

Editorial

El cambio climático el más grave y urgente desafío del planeta tierra y de la humanidad

Exponer como tópico Editorial el cambio climático representa una tarea de cierta complejidad, pero por su vital signi-ficado para el planeta y la propia humanidad, es un compromiso y deber nuestro, cuya difusión pueda suscitar y tener un mayor interés a nivel profesional y científico, y en general, un mejor conocimiento de sus impactos y cual debe y puede ser el aporte y comportamiento de cada quien en el tratamiento del más grande desafío global que nos afecta a todos.

El acelerado calentamiento de la temperatura en la Tierra se debe a un aumento en la emisión de gases de efecto invernadero, tales como el dióxido de carbono, monóxido de carbono y gases de azufre, cuyas fuentes son las emisiones de las industrias, la quema de residuos sólidos, quema de combustibles fósiles, principalmente utilizadas por los vehículos, entre otros. Esto puede medirse en la atmósfera y en los océanos. Una evidencia notoria es el deshielo de los casquetes polares, los lagos secos, la reducción de los hábitats para la fauna y flora terrestre, el incremento de la temperatura global, cambios climáticos, el blanqueo de los corales, el aumento del nivel del mar, entre otros. El cambio climático hace referencia al cambio de las condiciones climáticas, no solo de aumento de temperatura, incluye además, humedad, viento, lluvia y otros eventos meteorológicos. El calentamiento global se puede percibir en todo el planeta, mientras que el cambio climático se puede notar a escala regional o local. (https://ciifen.org/adaptacion-y-mitigacion/).

Según Harvelo Romero (junio 2021) refiriéndose al Informe de Expertos sobre Cambio Climático (IPCC) que señala el impacto del trastorno medioambiental en la naturaleza y la humanidad, advirtiendo que para el año 2050 se pronostica que 2.500 millones de personas más se verán afectadas por los riesgos vinculados al clima (olas de calor, inundaciones o daños a la agricultura relativos a sequías, abandono de hogares, aumento del hambre y las enfermedades. El aumento de temperatura entre 1,5 y 2 °C, 1.700 millones de personas más se verán expuestas a fuerte calor, 420 millones a calor extremo y 65 millones, a olas de calor excepcionales cada cinco años. El desplazamiento de mosquitos transmisores de enfermedades (dengue, fiebre amarilla, zika, …) a nuevas zonas geográficas podría amenazar a mitad de la humanidad. También las catástrofes naturales, que desde el 2008 para el 2050 entre 31 y 143 millones de habitan-tes de África subsahariana, el sureste asiático y América Latina serían desplazados dentro de sus países, por escasez de agua y agricultura y la subida del mar. En Europa las inundaciones costeras podrían multiplicarse al menos por 10. Muchos ecosistemas terrestres, marinos, costeros o de agua dulce ya están cerca de los límites con dificultad para adoptarse o "ya lo han superado". La Amazonía podría transformarse parcialmente en sabana. Otra amenaza es del permafrost que contiene volúmenes inmensos de metano, si la temperatura aumenta 2 °C, el 15 % podría expulsar gases agravando el cambio climático. Por otra parte, la economía sería otro grave problema, pues solo las inundaciones costeras podrían multiplicarse por 10 para 2050 hasta los 60 mil millones de dólares al año en las más grandes 136 ciudades costeras del mundo. Finalmente, si la temperatura aumentara 4°C, el PIB mundial podría perder entre 10 y un 23 % con respecto al de un mundo sin calentamiento global, pero limitar esa alza a solo 1,5 °C, el PIB per cápita de la mayoría de los países de África podría crecer un 5 % y hasta un 20 % para el 2100. El PCC en su 5° Informe señalaba que "en cada uno de los tres últimos decenios ha sido progresivamente más cálido en la superficie de la Tierra que cualquier decenio anterior desde 1850". Así, en América Latina y en el mundo entero, el cambio climático amenaza el crecimiento económico y la seguridad humana en formas complejas. Define la certeza científica como extremadamente probable en 95 % o más, y muy improbable con 10 % o menos. Entre los efectos observados: "los glaciares andinos

Continuación...

están retrocediendo y ello afecta a la distribución estacional del caudal de agua". También, "independientemente de las emisiones futuras, se prevé un mayor calentamiento". Plantea desafíos para el crecimiento y el desarrollo en América Latina con riesgos relacionados con el clima, tales como: disponibilidad de agua, las inundaciones y los deslizamientos de tierra, disminución de la producción y calidad de los alimentos, y con un nivel de certeza alto, propagación de enfermedades. Señala, que a finales del presente siglo, con riesgo alto o muy alto, de impactos graves, generalizados e irreversibles a nivel mundial. (www.ipcc.ch/report/ar5/syr).

Según la CEPAL, una mayor inserción de la economía circular permitirá a la región avanzar hacia un estilo de desarrollo más sostenible, incluyente y bajo en carbono apuntó Alicia Bárcena.(https://www.cepal.org/es/noticias/mayor-insercion-la-economia-circular-permitira-la-region-avanzar-un-estilo-desarrollo-mas). Ya en el año 2001 GreenFacts señalaba importantes cuestiones sobre el cambio climático en su evaluación. (https://www.greenfacts.org/es/cambio-climatico-ie3/l-2/cambio-climatico-6.htm). Navarro (2020). Terraformar la Tierra, rediseñar el mundo. CCCBLAB, visto lo complejo y difícil del desafío del cambio climático, plantea cambios globales de gran trascendencia. (https://lab.cccb.org/es/terraformar-la-tierra-redisenar-el-mundo/).

La NASA estudia cómo los incendios forestales del Ártico cambian el mundo. En 2014, mega fuegos en los territo-rios del noreste de Canadá quemaron más de siete millones de acres de bosque, liberando una cantidad de carbono a la atmósfera tan grande como la equivalente, por un año, por todas las plantas y árboles de Canadá, según SanderVer-averbeke (https://ciencia.nasa.gov/la-nasa-estudia-c%C3%B3mo-los-incendios-forestales-del-%C3%B3mo-los-incendios-forestales-del-%C3%A1rtico-cambian-el-mundo). En los últimos 20 años se ha tenido las tres temporadas de incendios más grandes registrados en Alaska, según María J. Viñas de la NASA. Numerosas investigaciones y descubrimientos científicos e innovaciones digitales y tecnológicas se proponen mitigar el cambio climático, entre ellas: drones que plantan árboles, Big data para evitar el desastre o reducir el derroche de recursos, innovaciones fotovoltaicas, desde paneles de bolsillo o tejas solares, enzimas que se comen el plástico, blockchain para ayudar al planeta, carne in vitro y a base de plantas, robots amigos. (https://aclima.eus/7-innovaciones-que-estan-ayudando-a-combatir-el-cambio-climatico/). Otras, como The Food Tech en su propuesta de 10 medidas para luchar contra el cambio climático expone interesantes contribución. (https://thefoodtech.com/historico/10-medidas-para-luchar-contra-el-cambio-climatico), y Armando Reyna. Acciones mundiales para contener el cambio climático. BBVA. también ofrece numerosas soluciones para enfrentar los impactos que cada vez son más destructivos. (https://www.bbva.com/es/sostenibilidad/acciones-mundiales-para-contener-el-cambio-climatico).

Finalmente, el IPCC, como uno de los más prestigiosos entes de expertos a nivel internacional ,en su Sexto Informe de Evaluación, insiste en enfatizar la gravedad existente y necesidad sin más retardo, de atender con recursos, acciones imprescindibles, consensos y urgencia, esta desafiante materia global, que compromete la normalidad planetaria y existencia de toda la vida terrestre. (https://archive.ipcc.ch/home_languages_main_spanish.shtml).

Sin duda, aunque hay cierto consenso entre las opiniones científicas mundiales de la imperiosa necesidad de enfrentar sin más retardo, disponiendo de los recursos necesarios y la toma de decisiones trascendentales, las soluciones pertinentes de carácter global, sobre el cambio climático, cada día será más costoso y difícil de emprenderlo y poder lograr las ambiciosas metas si continúan dándole largas los grandes poderes, intereses creados y gobiernos del planeta, en particular de los que más contaminan y rechazan los acuerdos como vinculantes, caso de China, India, Rusia y algunos otros países en vez de aceptar y sumarse a los acuerdos, como crucial y final esperanza, para el planeta y la humanidad, expuesto en la reciente Cumbre sobre Cambio Climático, celebrado en este pasado noviembre 21 en Glasgow, Escocia.

O futuro climático depende do controle social das decisões de investimento; análise de Luiz Marques (IFCH/Unicamp)

Do Acordo de Paris à COP 26. O que nos diz o dinheiro*

Texto Luiz Marques | Instituto de Filosofia e Ciências Humanas
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Edição de imagem Renan Garcia

"Quase tudo o que compreendemos hoje sobre o aquecimento global já era compreendido em 1979." Nathaniel Rich [1]

Há pouco mais de 40 anos, em 1979, dois eventos marcaram a história da formação do consenso científico sobre as mudanças climáticas. O primeiro, o Relatório encomendado pelo National Research Council dos EUA, coordenado por Jule Charney, afirmava [2]:

"Sabemos, há mais de um século, que mudanças na composição da atmosfera podem afetar sua capacidade de reter a energia do sol em nosso benefício. Temos agora evidência incontrovertível de que a atmosfera está de fato mudando e que nós próprios contribuímos para essa mudança. As concentrações atmosféricas de dióxido de carbono estão aumentando continuamente e essas mudanças estão ligadas ao uso humano de combustíveis fósseis e à exploração da terra".

O segundo evento, a 1a Conferência Mundial do Clima (WCC) em Genebra, teve a participação de cientistas de 50 nações e pode ser considerada a mais importante iniciativa científica global antes da criação do Painel Intergovernamental sobre as Mudanças Climáticas (IPCC). Estávamos, como dito, em 1979 e os cientistas concordavam já então ser "urgentemente necessário, para as nações do mundo, prever e evitar mudanças potencialmente antrópicas no clima que possam ser adversas ao bem-estar da humanidade".[3]

O ano de 1988 trouxe três outros marcos fundamentais nessa história: 1. a criação do IPCC; 2. o famoso depoimento de James Hansen apresentado à Comissão de Energia e Recursos Naturais do Senado dos EUA, no qual o cientista afirmava: "O aquecimento global é agora grande o suficiente para ser atribuível com alto grau de confiança, em uma relação de causa a efeito, ao efeito estufa (…) O efeito estufa foi detectado e está mudando nosso clima agora" [4]; 3. a Conferência de Toronto sobre as Mudanças Climáticas, considerada a primeira grande conferência intergovernamental sobre as mudanças climáticas, reuniu 340 participantes de 46 países. Sua declaração final antecipava o que todos hoje sabemos: "A humanidade está conduzindo um experimento não intencional, descontrolado e globalmente abrangente cujas consequências últimas são superadas apenas por uma guerra nuclear global".[5]

Desde 1979, passando por 1988 e pela estruturante ECO-92, criadora, por exemplo, da Convenção-Quadro das Nações Unidas sobre as Mudanças Climáticas (UNFCCC), dois mundos evoluem em trajetórias divergentes. O primeiro é o dos dados, impactos e alertas dos cientistas sobre a emergência climática, ecoados hoje nas retóricas ruidosas, e mais ou menos vazias, de "sustentabilidade" dos governantes; o outro é o mundo silencioso do dinheiro, isto é, dos investimentos e, em geral, de tudo o que se orienta pela lógica expansiva do sistema econômico. A distância crescente entre esses dois mundos mede-se de modo particularmente didático no descompasso entre os objetivos do Acordo de Paris, de Dezembro de 2015 e as ações que a consecução desses objetivos suporia na governança e na atividade econômica. Embora sobejamente conhecidos, convém relembrar os objetivos desse Acordo, formulados em seu artigo 2, parágrafo 1: [6]

* https://www.ecodebate.com.br/2021/10/01/o-futuro-climatico-depende-do-controle-social-das-decisoes-de-investimento/

Aprimorando a implementação da Convenção [UNFCCC] e de seu objetivo, [7] este Acordo visa fortalecer a resposta global à ameaça das mudanças climáticas, no contexto do desenvolvimento sustentável e dos esforços para erradicar a pobreza, incluindo:

(a) Manter o aumento da temperatura média global bem abaixo de 2°C acima dos níveis pré-industriais e envidar esforços para limitar o aumento da temperatura a 1,5°C acima dos níveis pré-industriais, reconhecendo que isso reduziria significativamente os riscos e impactos das mudanças climáticas;

(b) Aumentar a capacidade de adaptação aos impactos adversos das mudanças climáticas, promover a resiliência climática e o desenvolvimento com baixas emissões de gases de efeito estufa, de modo a não ameaçar a produção de alimentos; e

(c) Tornar os fluxos financeiros consistentes com um cenário de baixas emissões de gases de efeito estufa e desenvolvimento resiliente ao clima.

Digamos sem rodeios: passados 43 anos de "evidência incontrovertível" das mudanças climáticas e quase 6 anos do Acordo de Paris, sua trajetória atual é de aceleração em sentido diametralmente oposto ao seu objetivo central: conter o aquecimento médio global "bem abaixo" de 2oC em relação ao período pré-industrial. Isso porque, como bem mostrou o IPCC em 2018 [8], os impactos de um planeta cujas temperaturas médias excedem esse limite de aquecimento praticamente inviabilizam uma sociedade organizada. Estamos, de fato, evoluindo no sentido oposto às metas do Acordo de Paris, que supõem diminuir as emissões e concentrações atmosféricas de Gases de Efeito Estufa (GEE): o relatório de dezembro de 2020 do PBL Netherlands Environmental Assessment Agency, segundo dados do EDGAR (Emission Database for Global Atmospheric Research), afirma que: [9]

"As emissões globais de GEE em 2019 atingiram 57,4 GtCO2e [bilhões de toneladas de dióxido de carbono equivalente] [10], quando incluídas as emissões causadas pelas mudanças no uso do solo (estimadas com muita incerteza em 5 GtCO2e +/-50%), o que representa um aumento de 70% em relação a 2018."

A Figura 1 mostra a evolução dessas emissões entre 1990 e 2019.

Em 2019, "o crescimento das emissões totais dos GEE (excetuadas as emissões derivadas das mudanças de uso do solo) continuaram a crescer à taxa de 1,1% (±1%)". Trata-se da mesma taxa de crescimento do passado recente, pois "as emissões globais aumentaram à taxa média de 1,1% ao ano entre 2012 e 2019". Além disso, em 2019, as emissões de GEE estavam cerca de 59% mais altas do que em 1990 e 44% mais altas do que em 2000 (em todos os casos citados, sem contar as emissões decorrentes da mudança de uso de solo, sobretudo desmatamento)[11]. Em 2020, a pandemia da Covid-19 derrubou as emissões de CO2 em quase 2 bilhões de toneladas, ou cerca de 6%, sobretudo por causa da diminuição do uso de petróleo para o transporte rodoviário e para a aviação. Trata-se, consoante a Agência Internacional de Energia (AIE), do maior declínio anual desde a II Grande Guerra. Mas já em Dezembro de 2020, as emissões de GEE relacionadas à geração de energia ultrapassaram em 2% as emissões de Dezembro de 2019. Na China, houve um aumento de

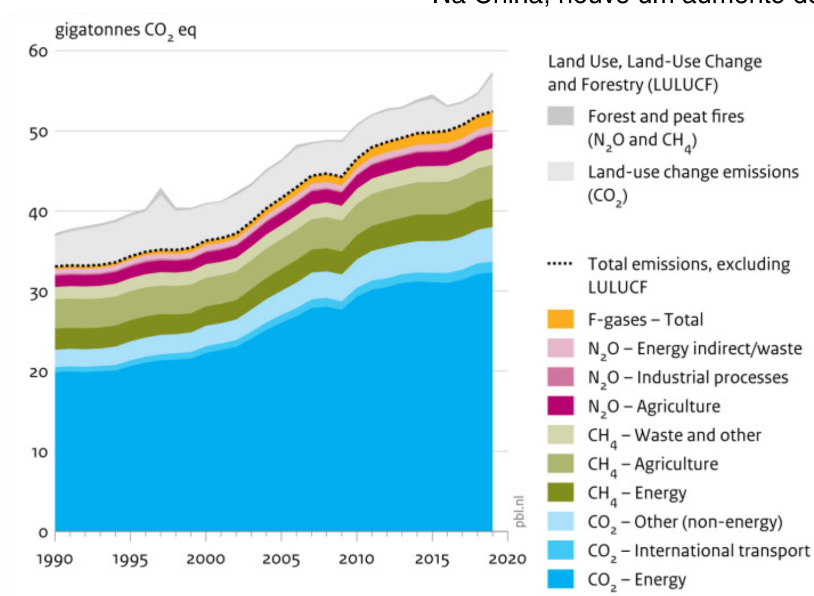

Figura 1 – Emissões globais de gases de efeito estufa (GEE) entre 1990 e 2019, por tipo de gás (CO2, CH4, N2O e gases fluorados) e por fontes de emissões (energia, transporte, agropecuária, processos industriais, uso do solo, mudança do uso do solo e indústria madeireira). Fonte: J.G.J. Olivier & J.A.H.W. Peters, "Trends in Global CO2 and Total Greenhouse Gas Emissions 2020 Report". PBL Netherlands Environmental Assessment Agency, 20/XII/2020, p. 17.

0,8% das emissões de GEE em 2020 em relação a 2019. Na Índia e no Brasil, as emissões de 2020 superaram as de 2019 a partir do 4º quarto do ano. Em Março de 2021, Fatih Birol, diretor-executivo da AIE, soou o alarme[12]:

"A recuperação das emissões globais de carbono no final do ano passado é um forte aviso de que não se está fazendo o suficiente para acelerar as transições de energia limpa no mundo. Se os governos não agirem rapidamente com as políticas de energia certas, podem colocar em risco a oportunidade histórica mundial de fazer de 2019 o pico definitivo das emissões globais."

A COP25 (Madrid, 2019) apenas reforçou os bloqueios do Acordo de Paris (a mercantilização do carbono, previsto no artigo 6, por exemplo) [13], em parte atribuíveis à sabotagem das delegações dos EUA, da Austrália e do Brasil, vencedor do "Prêmio Fóssil do Ano" por retrocessos ambientais.[14] Os prognósticos da COP26, que se abrirá em Novembro de 2021 em Glasgow, não parecem reverter a percepção de que o Acordo de Paris já está condenado a um desfecho substancialmente análogo ao do desastroso Protocolo de Kyoto (1997-2012).

1. Siga o dinheiro

Declarar o fracasso do Acordo de Paris pode parecer demasiado precipitado. Mas não é. James Hansen já o havia previsto em 2015 [15] e tinha razão, pois é preciso olhar o que as melodiosas promessas governamentais ocultam: o dinheiro. Os investimentos e financiamentos mostram que não há em curso nenhuma transição energética relevante para a contenção do aquecimento global. A AIE liquidou os últimos vestígios de credibilidade dessa fábula da transição energética, ao lançar seu relatório "Net Zero by 2050", um roteiro da Agência para balizar os novos compromissos apresentados à COP26. Suas projeções vão até 2030 e 2050 e sua mensagem central é simples: 1. manter uma chance razoável de conter as metas do Acordo de Paris de um aquecimento médio global entre 1,5oC e 2oC requer que as emissões líquidas (ou seja, além das que os sistemas naturais do planeta podem absorver) de carbono sejam zeradas até 2050; 2. para zerar essas emissões líquidas em 2050, é preciso zerar agora os investimentos em combustíveis fósseis. Dito na linguagem não prescritiva da AIE, "não há necessidade de investimentos em nova oferta de combustíveis fósseis em nossa trajetória para zero emissões líquidas de carbono" [em 2050][16]. Isso significa, repita-se, que qualquer investimento suplementar em energia fóssil hoje impede conter o aquecimento médio global em 2oC acima do período pré-industrial.

Ocorre que os investimentos globais em energias fósseis não dão sinais de declínio. Pelo contrário. Desde o Acordo de Paris (2015), o World Bank investiu mais de US$ 12 bilhões em combustíveis fósseis, dos quais US$ 10,5 bilhões em financiamento de novos projetos em energia fóssil. [17] Mas há pior que isso: entre 2016 e 2020, os 60 maiores bancos do mundo financiaram a indústria de combustíveis fósseis com recursos no valor de US$ 3,8 trilhões,[18] um montante mais de duas vezes maior que o PIB do Brasil em 2019 (US$ 1,84 trilhão). Esses financiamentos aumentam ano a ano entre 2016 e 2019, e mesmo os de 2020, malgrado a pandemia da Covid-19, foram superiores aos de 2016 e de 2017, conforme mostra a Tabela 1:

Tabela 1 – Financiamentos da indústria de combustíveis fósseis pelos 60 maiores bancos do mundo entre 2016 e 2020 (em bilhões de dólares).

Ano	2016	2017	2018	2019	2020
Bilhões (US$)	709,2	740,4	780,9	823,6	750,7

Fonte: *Banking on Climate Chaos. Fossil Fuel Finance Report*, 2021 <https://www.ran.org/bankingonclimatechaos2021/>.

Graças a esses financiamentos, os upstream investments em petróleo e gás natural, ou seja, investimentos em estudos de viabilidade, prospecção, plataformas, locação de equipamentos, perfuração, extração etc. vêm aumentando entre 2016-2019, como mostra a Figura 2.

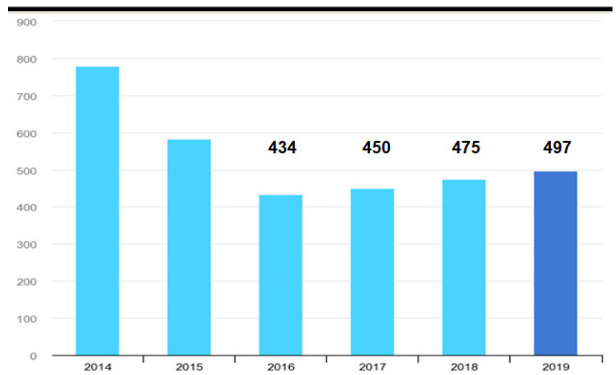

Figura 2 – Investimentos globais em produção (upstream) de petróleo e de gás natural entre 2014 e 2019, em bilhões de dólares. Fonte: IEA, Oil 2019. Analysis and Forecast to 2024.

Os 30 bancos e as "expansionistas do Ártico"

O Ártico, ecossistema tão rico, frágil e vulnerável quanto abundante em petróleo e gás natural, está atraindo sempre mais investimentos e subscrições de bancos e seguradoras, além de gestores de ativos (Assets under management), como BlackRock, Vanguard e Crédit Agricole (via Amundi). O Arctic

Monitoring and Assessment Programme (AMAP) lista 599 localidades com potencial para a produção de petróleo e gás na região. Desse total, 220 sítios, contendo 130 bilhões de barris de petróleo equivalente (BOE), já estão sendo explorados em 2021, 25 dos quais em águas profundas, com alto risco de desastres ambientais. Esses 220 sítios já operacionais produziram 4 bilhões de barris de petróleo apenas em 2020 e emitiram 1,3 bilhão de toneladas de CO2e, ou seja, mais que as emissões do Japão em 2018. Outros 39 sítios, contendo 147 bilhões de BOE, encontram-se em fase de estudos e planejamento e há ainda 338 sítios, contendo 266 bilhões de BOE exploráveis com a tecnologia atual, o que representaria 15% do aumento global previsto da produção de petróleo até 2030. As perspectivas econômicas de expansão da exploração de combustíveis fósseis no Ártico são de 20% de crescimento da produção entre 2022 e 2026, com grandes lucros para as corporações envolvidas, as "expansionistas do Ártico", como as chama a Reclaim Finance. [19] A mais importante delas é a Gazprom, reestatizada por Vladimir Putin em 2000, com 74% de suas reservas de petróleo e gás natural localizadas no Ártico. O setor financeiro público e privado é, como sempre, o nervo da guerra, no caso a guerra de extermínio movida pelo capitalismo contra a vida planetária. Os números são eloquentes: [20]

"De 2016 a 2020, os bancos comerciais canalizaram US$ 314 bilhões para as expansionistas do Ártico em empréstimos e subscrições. Até Março de 2021, os investidores detinham cerca de US$ 272 bilhões nessas mesmas empresas em ações e títulos. (…) 80% de todos os empréstimos e subscrições para os expansionistas do Ártico provieram de apenas 30 bancos".

O círculo vicioso do aquecimento

Observa-se no Ártico, que já se aquece duas a três vezes mais rapidamente que a média global, uma perigosíssima alça de retroalimentação do aquecimento. O rápido degelo em curso em toda essa região, causado em parte pela queima de combustíveis fósseis, aumenta a oferta desses combustíveis, pois quanto menos gelo na região, mais fáceis se tornam a exploração de suas jazidas de petróleo e gás natural e sua exportação. O círculo vicioso é impulsionado também pelo fato de que o gelo é escurecido pela fuligem emitida por essa exploração, o que aumenta a absorção da radiação solar na região (diminuição do albedo), acelerando ainda mais o degelo e, portanto, o aquecimento. Além disso, o derretimento do gelo e dos solos permanentemente gelados (permafrost) ativa a metabolização do material orgânico pelas bactérias, o que engendra a liberação de quantidades crescentes de metano, um poderosíssimo GEE, responsável já por 20% a 30% do aquecimento global.[21] Outrora aprisionado no permafrost e nos hidratos de metano do raso leito marinho da plataforma continental da Sibéria, o metano começa a ser liberado em quantidades crescentes na atmosfera. Estima-se que os depósitos rasos de hidratos de metano ocupem atualmente cerca de 57% (1,25 milhões de km2) do leito da Plataforma Marinha da Sibéria Oriental (ESAS), particularmente rasa, pois três quartos de sua área de 2,5 milhões de km2 estão a menos de 40 metros de profundidade. A ESAS pode preservar mais de 1.400 Gt de metano, o que torna esta região o maior e mais vulnerável depósito de metano (CH4) submarino no mundo. Quão rapidamente esse metano será liberado é incerto, mas essa liberação está se acelerando.[22]

2. O quinhão do King Coal

O carvão foi também bem aquinhoado por investimentos de parte do setor financeiro, conforme informações de uma coalizão de ONGs, publicadas em Fevereiro de 2021. Globalmente, os bancos comerciais canalizaram mais recursos (em empréstimos e subscrições) [23] para o carvão em 2020 (US$ 543 bilhões até outubro desse ano) do que em 2016 (US$ 491 bilhões), um aumento de 11% desde que o Acordo de Paris entrou em vigência, como mostra a Figura 3.

Em janeiro de 2021, 4.488 investidores institucionais estavam

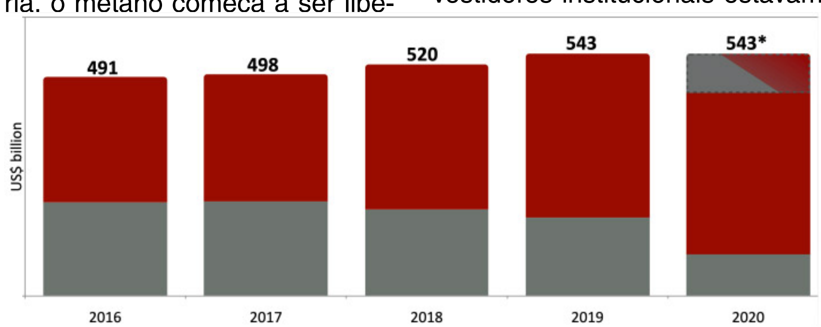

Figura 3 – Empréstimos bancários e subscrições por bancos comerciais para a indústria do carvão entre 2016 e 2020 em bilhões de dólares. A parte de baixo de cada coluna representa os empréstimos e a parte de cima, as subscrições. Fonte: Urgewald, Reclaim Finance, Rainforest Action Network, 350.org Japan e 25 ONGs parceiras, "Groundbreaking Research Reveals the Financiers of the Coal Industry". Fevereiro de 2021.
Nota: *Dados até Outubro de 2020, com extrapolação até Dezembro.

colocando globalmente recursos da ordem de US$ 1,03 trilhão em companhias que operam ao longo das cadeias de valor do carvão térmico [24]. Em 2018, a Rússia produziu 439 milhões de toneladas (Mt) de carvão e os diversos cenários de produção em 2035 oscilam entre 383 e 703 Mt [25]. O país planeja, até 2040, diminuir seu consumo de carvão em… 8%. A Joint-Stock Company Siberian Coal Energy Company (JSC SUEK), a maior corporação de mineração de carvão da Rússia, ostenta uma produção de mais de 100 Mt de carvão por ano e tem planos para um incremento de 25 Mt adicionais na região de Kuzbass (SO da Sibéria). Em 2021, seu CEO, Stepan Solzhenitsyn (filho de Aleksander Solzhenitsyn), mandatou nove bancos, três ocidentais, um chinês e cinco russos, para, na qualidade de Joint Lead Managers e Joint Bookrunners, oferecer títulos em dólares, com vencimento em 5 anos, de modo a viabilizar esse incremento, que inclui ainda maior capacitação de seus portos de exportação.[26]

Em meio a esse péssimo quadro, há duas boas notícias: em maio de 2021, o G7 declarou que, a partir de 2022, não irá mais financiar projetos internacionais de usinas termelétricas movidas a carvão e, em setembro, Xi Jinping também declarou que a China não mais financiará projetos similares fora de seu território. Resta saber se essas declarações serão confirmadas pelos fatos. Em todo o caso, os financiamentos já contratados são de longo prazo e, no caso da China, esses financiamentos representam 40% dos US$ 42 bilhões já comprometidos globalmente com o carvão entre 2013 e 2019 em 18 países particularmente carentes de eletrificação: Bangladesh, Paquistão, Índia, Angola, Burkina Faso, Chade, República Democrática do Congo, Etiópia, Quênia, Madagascar, Malawi, Moçambique, Níger, Nigéria, Sudão, Sudão do Sul, Uganda e Tanzânia. [27] Vale lembrar, por fim, que qualquer CO_2 emitido permanece em grande parte por milênios na atmosfera e continuará aquecendo a atmosfera.

3. Os Estados-Corporações

Quando se trata da indústria de combustíveis fósseis, não há diferença entre bancos e Estados. Segundo um documento de abril de 2021 do Energy Policy Tracker, no intervalo de apenas 12 meses os governos do G20 comprometeram recursos públicos no valor de US$ 297,28 bilhões para a manutenção e acréscimo da matriz energética fóssil, significativamente mais do que os recursos canalizados para as energias renováveis de baixo carbono (US$ 234,36 bilhões).[28] No esforço da humanidade de abandonar os combustíveis fósseis com o necessário senso de urgência, competiria aos Estados impor aos mercados uma nova política energética, incluindo investimentos sustentados de muitos trilhões de dólares em energias renováveis de baixo carbono e na eletrificação dos transportes, fim dos subsídios aos combustíveis fósseis (prometidos pelo G20 desde 2009…), transferência desses subsídios para as energias de baixo carbono, impostos crescentes sobre as emissões de GEE, barreiras comerciais aos países mais emissores etc. Os Estados estão fazendo justamente o contrário disso e vale lembrar aqui apenas um exemplo: entre 2017 e 2019, o G20 subsidiou os combustíveis fósseis em US$ 584 bilhões por ano na média entre esses três anos, através de transferências orçamentárias, políticas fiscais, subsídios tarifários, finanças públicas e investimentos em suas estatais[29]. Muitas e complexas são as causas da conivência dos Estados com a indústria de combustíveis fósseis, mas a primeira delas é simples: os Estados são os maiores proprietários das reservas de combustíveis fósseis existentes na crosta terrestre e estão também entre os maiores controladores das empresas que as exploram, além de serem fortemente dependentes das receitas geradas por essa exploração. É o que já em 2010 Ian Bremmer relatava num famoso artigo do Wall Street Journal [30]:

"As 13 maiores companhias de energia da Terra, medidas pelas reservas que elas controlam, são hoje de propriedade dos Estados e são por eles operadas. Saudi Aramco, Gazprom (Rússia), China National Petroleum Corp., National Iranian Oil Co., Petróleos de Venezuela, Petrobras (Brasil) e Petronas (Malásia) são todas maiores do que a ExxonMobil, a maior das multinacionais [em energia]. Coletivamente, as multinacionais de petróleo exploram apenas 10% das reservas mundiais de petróleo e gás natural. As companhias estatais controlam agora mais de 75% de toda a produção de petróleo."

Essas proporções evocadas por Ian Bremmer podem variar no tempo e segundo diferentes critérios. Por exemplo, se a data for 2019 e se o critério adotado forem receitas (e não reservas), quatro das cinco maiores companhias de petróleo e gás do mundo são estatais [31] (Sinopec, CNPC, PetroChina e Saudi Aramco) e somam receitas de mais de US$ 1,5 trilhão.[32] Se o critério for volume de produção, das dez maiores companhias de petróleo do mundo, oito são estatais (Saudi Aramco, Rosneft, KPC, NIOC, CNPC, Petrobrás, ADNOC e Pemex) e produzem mais de 30 milhões de barris de petróleo por dia, cerca de um terço da produção global em 2018. [33] Nenhum dos diferentes critérios de avaliação altera o fato de que as corporações estatais produzem mais da metade do petróleo e do gás no mundo. Richard Heede, do Climate Accountability Institute, mostrou que entre 1965 e 2017, as 20 maiores corporações de combustíveis fósseis contribuíram com 480 GtCO2e ou 35% das emissões das mais de 1.354 bilhões de toneladas de CO2 e metano diretamente relacionadas à produção de energia. E as 12 estatais desse setor contribuíram com 262,7 GtCO2e ou 54,6% das emissões desse grupo das 20 Majors, conforme discriminado na Figura 4.

Segundo um relatório de 2021, essas estatais têm projetos em upstream investments de quase

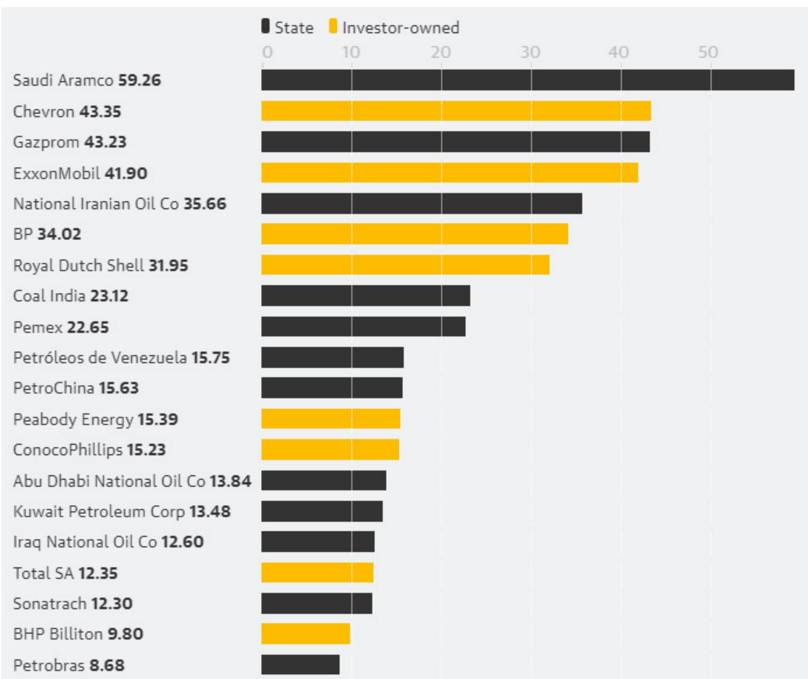

Figura 4 – As 20 companhias que contribuíram com 480 Gigatoneladas de CO2-equivalente (GtCO2e) ou 35% das emissões globais de 1.354 GtCO2e entre 1965 e 2012, 12 das quais estatais, com suas respectivas contribuições. Fonte: Matthew Taylor & Jonathan Watts, "Revealed: the 20 firms behind a third of all carbon emissions". The Guardian, 9/X/2019, baseado em Richard Heede, Carbon Majors: Updating activity data, adding entities, & calculating emissions: A Training Manual, Climate Accountability Institute, Snowmass, Colorado, Setembro de 2019.

US$ 2 trilhões ao longo desta terceira década do século.[34] Além desses investimentos, os Estados detêm, apenas em reservas de petróleo e gás, ativos da ordem de US$ 3 trilhões. Não por acaso, portanto, malgrado sua retórica e promessas, os Estados não apenas não estão liderando a transição energética, mas estão apostando em seu retardamento para perder o menos possível de seus ativos.[35] Como bem afirma Fiona Harvey, tanto quanto as multinacionais privadas, as estatais "têm nosso clima em suas mãos".[36] Se seus planos de investimentos forem efetivados nos próximos anos (e na ausência de governança global efetiva, não há autoridade que os impeça), as emissões GEE lançados à atmosfera vão estourar o orçamento carbono ainda disponível para conter o aquecimento global em 2ºC.

4. O limite para um aquecimento de 1,5oC e 2oC era 2020

Todas as projeções sobre o aquecimento global neste decênio e no próximo são claras e bem conhecidas: a data limite para iniciar a diminuição das emissões de GEE, de modo a manter uma chance razoável de conter o aquecimento global entre 1,5ºC e 2ºC já passou: era 2020. Esse consenso emergiu com força na comunidade científica entre 2017 e 2019, a começar por três lideranças do IPCC: Jean Jouzel, ex-vice-presidente do IPCC afirmou em 2017: "Para manter alguma chance de permanecer abaixo dos 2ºC é necessário que o pico das emissões seja atingido no mais tardar em 2020" [37]. Thomas Stocker, co-diretor do IPCC (2008-2015) afirmou em 2019 algo similar: "O ano de 2020 é crucial para a definição das ambições globais sobre a redução das emissões. Se as emissões de 2ºC continuarem a aumentar além dessa data, as metas mais ambiciosas de mitigação tornar-se-ão inatingíveis"[38]. Por sua vez, Hoesung Lee, atual presidente do IPCC, em seu discurso de abertura da COP25, em Dezembro de 2019 alertou os diplomatas e o mundo: "Nossas avaliações mostram que a estabilização das mudanças climáticas requer que as emissões de gases de efeito estufa atinjam seu pico no próximo ano, mas as emissões continuam a crescer, sem dar sinal de inflexão num futuro próximo." [39] Para dirimir possíveis dúvidas a respeito, a Figura 5 mostra os três cenários finais de salvaguarda de nosso clima (2016, 2020 e 2025), sendo o de 2025 considerado já excessivamente tardio. [40]

Nos três cenários, as emissões deveriam cair cerca de 50% (20 GtCO2) em relação aos níveis de 2017 por volta de 2030. Isso significa que teriam que estar então nos níveis de 1977 e nos de 1955 em termos de emissões per capita.[41] Como afirmam com razão os autores, o cenário com pico das emissões em 2025 "deixa demasiado pouco tempo para transformar a economia". Por outro lado, se orçamento carbo-

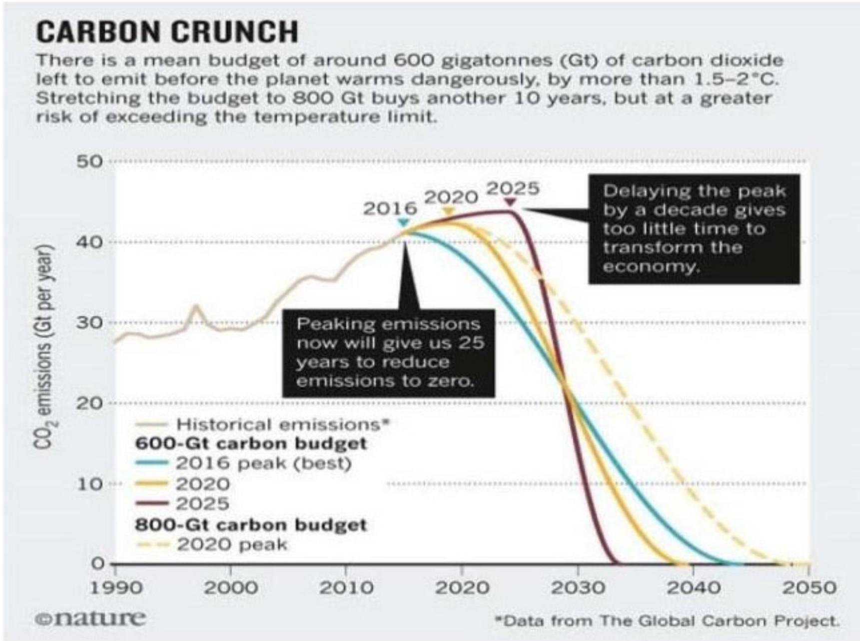

Figura 5 – Curvas de declínio das emissões de CO2 requeridas para se manter o aquecimento médio global superficial do planeta entre 1,5ºC e 2ºC acima do período pré-industrial, segundo a premissa de um orçamento carbono de 600 Gt, com cenários de picos de emissões em 2016, 2020 e 2025. Fonte: Christiana Figueres, Hans Joachim Schellnhuber, Gail Whiteman, Johan Rockström, Anthony Hobley & Stefan Rahmstorf, "Three years to safeguard our climate". Nature, 29/VI/2017.

no for de 800 GtCO2 com pico das emissões em 2020, obtém-se a data de 2050 para zerar as emissões líquidas (linha pontilhada), mas com "grande risco de exceder a temperatura limite". É extremamente inverossímil que o pico das emissões ocorra mesmo em 2025, dados os níveis de investimento e de financiamento da produção de combustíveis fósseis já engajados desde 2016. Cada tonelada suplementar de GEE emitida após 2020 aumenta exponencialmente a chance de se ultrapassar um aquecimento de 2ºC, nível atingido no segundo quarto deste século, provavelmente nos anos 2030. [42] Como já afirmado no início, segundo o IPCC (2018), uma sociedade organizada torna-se inviável num planeta cujas temperaturas médias excedem 2oC em relação ao período pré-industrial. Temos, portanto, mantida a atual trajetória, não mais que uma década para salvaguardar um mínimo de segurança existencial, a começar por nossa segurança alimentar: "até 2040, a proporção das safras globais afetadas por secas graves – equivalente à sofrida pela Europa Central em 2018 (50% de redução da safra) – aumentará provavelmente para 32% a cada ano, mais do triplo da média histórica". [43]

5. Conclusão: a interdependência entre clima e democracia

As 20 nações que compõem o G20 são responsáveis por cerca de 75% das emissões globais de GEE e poderiam limitar o aquecimento médio global em 1,7ºC até o final do século, segundo um estudo recente do World Resources Institute.[44] Reunidos mais uma vez em Glasgow em Novembro, os diplomatas do G20 não terão poder para tanto, mesmo se, ao invés de se entrincheirarem na defesa de interesses nacionais, fossem capazes de se unir na defesa de nossa "Casa Comum". Mudar o modelo econômico termo-fóssil, expansivo e globalizado que nos ameaça existencialmente requereria o engajamento dos bancos e dos grandes investidores. O problema é que eles não precisam de nós. As sociedades não estão incluídas em seus planos. O dinheiro não segue os discursos "verdes", governamentais e corporativos, de modo que os investimentos na indústria de combustíveis fósseis vão, como visto, de vento em popa. Portanto, se as sociedades decidirem reagir à emergência climática, elas terão de fazê-lo sem os bancos e, sobretudo, contra os bancos. Após mais de quatro decênios de fracassos das políticas incrementais, impõe-se entender que o gradualismo não está nem mesmo desacelerando o aquecimento global. Precisamos agora de rupturas sistêmicas, em nível civilizacional. Para começar, abandonar o dogma do crescimento econômico e os parâmetros irracionais, entre os quais o PIB, pelos quais o capitalismo mede seu desempenho. Eis o cerne do problema: precisamos vencer a batalha política pelo controle social das decisões de investimento, seja das corporações, seja dos Estados-Corporações. E esse controle social dos recursos estratégicos da sociedade só poderá ser conquistado por meio de dois processos simultâneos: (a) a democratização radical do Estado, em particular no que se refere às decisões sobre investimentos em energia e alimentação e (b) a superação do axioma da soberania nacional absoluta, em prol de uma governança global democrática. Democracia e clima são, na realidade, duas faces da mesma moeda.

Nunca, ao menos nos registros históricos disponíveis, o Homo sapiens esteve numa encruzilhada tão crucial e diante de um desafio tão complexo – político, científico, filosófico e espiritual – como o que hoje enfrentamos. Há muitas razões para nos sentirmos desencorajados, mas há uma razão, decisiva, a nos encorajar: vencer esse desafio ainda depende de nossa capacidade de compreensão, intelectual e emocional, do que está em jogo. Se continuarmos a nos iludir com gradualismos, será muito em breve tarde demais. A partir do próximo decênio, quando o aquecimento médio global estiver próximo (aquém ou além) de 2ºC acima do período pré-industrial, o planeta que as corporações e os Estados-Corporações tiverem criado já será irreconhecível e terrivelmente hostil à nossa e a inúmeras outras espécies. As alças de retroalimentação do aquecimento global começarão então a decidir nosso destino por nós. [45]

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1 Cf. Nathaniel Rich, Losing Earth. A Recent History, Nova York, 2019: "Nearly everything we understand about global warming was understood in 1979."

2 Cf. Jule Charney (coord.), "Carbon Dioxide and Climate: A Scientific Assessment. Report of as Ad Hoc Study on Carbon Dioxide and Climate". Woods Hole, Massachusetts, apresentado ao Climate Research Board, National Research Council, 23-27/VII/1979.

3 Cf. Organização Meteorológica Mundial (WMO), "A history of climate activities". The 1979 World Climate Conference Declaration: "Having regard to the all-pervading influence of climate on human society and on many fields of human activities and endeavour, the Conference finds that it is now urgently necessary for the nations of the world (…) to foresee and prevent potential man-made changes in climate that might be adverse to the well-being of humanity".

4 Cf. "Congressional Testimony of Dr. James Hansen" (23/VI/1988): "the global warming is now large enough that we can ascribe with a high degree of confidence a cause and effect relationship to the greenhouse effect. (…) The greenhouse effect has been detected, and it is changing our climate now."

5 Cf. The Changing Atmosphere. Implications for Global Security. Conference Statement, p. 292: "Humanity is conducting an uninte

6 Veja-se

7 O objetivo da UNFCCC (United Nations Frame Convention on Climate Change) ou Convenção-Quadro das Nações Unidas sobre as Mudanças Climáticas é definido em seu artigo 2: "O objetivo último desta Convenção (…) é alcançar (…) a estabilização das concentrações de GEE na atmosfera em um nível que evite interferências antrópicas perigosas no sistema climático. Esse nível deve ser alcançado em um período de tempo suficiente para permitir que os ecossistemas se adaptem naturalmente às mudanças climáticas, para garantir que a produção de alimentos não seja ameaçada e para possibilitar ao desenvolvimento econômico prosseguir de maneira sustentável".

8 Cf. IPCC (2018) – Global Warming of 1.5°C.An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R.Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T.Waterfield (eds.)]

9 Cf. J.G.J. Olivier & J.A.H.W. Peters, "Trends in Global CO 2 and Total Greenhouse Gas Emissions 2020 Report". PBL Netherlands Environmental Assessment Agency, 20/XII/2020.

10 O termo CO 2 -equivalente (CO 2 -eq ou CO 2 e) designa o conjunto das emissões de gases de efeito estufa (sobretudo CO 2 + CH 4 + N 2 O) medidas em função do potencial de aquecimento global do CO 2 .

11 Cf. Olivier & Peters, cit. (2020): "In 2019, the growth in total global greenhouse gas (GHG) emissions (excluding those from land-use change) continued at a rate of 1.1% (±1%). (…) "Global greenhouse gas (GHG) emissions have increased, on average, by 1.1% per year, from 2012 to 2019. (…) The 2019 global GHG emissions excluding those from land-use change were about 59% higher than in 1990 and 44% higher than in 2000".

12 "Global energy-related CO 2 emissions were 2% higher in December 2020 than in the same month a year earlier, according to IEA data, driven by economic recovery and a lack of clean energy policies". AIE, 2/III/2021.

13 Sobre o obscuro artigo 6 do Acordo de Paris

14 Cf. "Brasil, EUA e Austrália são acusados de bloquear avanços na COP 25" e "COP 25: Brasil 'vence' prêmio Fóssil do Ano por retrocessos ambientais". Carta Capital, 13/XII/2019.

15 Cf. Oliver Milman, "James Hansen, father of climate change awareness, calls Paris talks, 'a fraud'". The Guardian, 12/XII/2015.

16 Cf. AIE, "Net Zero by 2050. A Roadmap for the Global Energy Sector", Maio de 2021, 3 a revisão, Julho de 2021: "there is no need for investment in new fossil fuel supply in our net zero pathway".

17 Cf. "World Bank Annual Meeting: Bank invested over $ 10.5 billion in fossil fuels since Paris Agreement". Urgewald, 12/X/2020.

18 Cf. Banking on Climate Chaos. Fossil Fuel Finance Report, 2021, Rainforest Action Network, Banktrack, Indigenous Environmental Network, Sierra Club, Oil Change International e Reclaim Finance.

19 Cf. Reclaim Finance, "Protecting the Arctic from Oil and Gas Expansion". Setembro de 2021. Para o relatório completo, cf. Eren Can Ileri, Henri Her, Alix Mazounie & Lucie Pinson, Drill, Baby, Drill. How banks, investors and insurers are driving oil and gas expansion in the Arctic. Setembro de 2021, 24 p.

20 Reclaim Finance, IX/2021: "from 2016 to 2020, commercial banks channeled $314 billion to Arctic expansionists in loans and underwriting. As of March 2021, investors held roughly $272 billion in those same companies in shares and bonds (…) 80% of all loans and underwriting to Arctic expansionists comes from just 30 banks".

21 Sobre a importância do metano como GEE, cf. Gavin Schmidt, "Methane: A Scientific Journey from Obscurity to Climate Super-Stardom". Goddard Institute for Space Studies, Setembro de 2004; E. M. Herndon, "Permafrost slowly exhales methane". Nature Climate Change, 8, 4, April 2018, pp. 273-274; Joshua F. Dean et al., "Methane Feedbacks to the Global Climate System in a Warmer World". Reviews of Geophysics, 56, 15/II/2018; Christian Knoblauch et al., "Methane production as key to the greenhouse gas budget of thawing permafrost". Nature Climate Change, 8, 19/III/2018, pp. 309-312; Sara E. Mikaloff Fletcher & Hinrich Schaefer, "Rising methane: A new climate challenge". Science, 364, 6444, 7/VI/2019, pp. 932-933; Katrin Kohnert, "Strong geologic methane emissions from discontinuous terrestrial permafrost in the Mackenzie Delta, Canada". Scientific Reports, 19/VII/2017.

22 Cf. Natalia Shakhova et al., "Current rates and mechanisms of subsea permafrost degradation in the East Siberian Arctic Shelf". Nature Communications, 22/VII/2017; Natalia Shakhova, Igor Semiletov & Evgeny Chuvilin, "Understanding the Permafrost–Hydrate System and Associated Methane Releases in the East Siberian Arctic Shelf". Geosciences, 9, 6, 251, 2019; Peter Wadhams, A Farewell to ice. A Report from the Arctic. London, 2016; Luiz Marques, "Climate Feedbacks and Tipping Points". Capítulo 8 de Capitalism and Environmental Collapse, Springer, 2020, pp. 199 – 232.

23 Uma subscrição refere-se ao processo pelo qual os bancos captam investimentos para empresas emitindo títulos ou ações em seu nome e vendendo-os a investidores, como fundos de pensão, seguradoras, fundos mútuos etc.

24 Cf. Urgewald (com a colaboração de Reclaim Finance, Rainforest Action Network, 350.org Japan e 25 outras ONGs parceiras), "Groundbreaking Research Reveals the Financiers of the Coal Industry". 25/II/2021; Cecilia Jamasmie, "World's two largest asset managers have invested $ 170 bn in coal". Mining(dot)com.

25 Cf. Yelena Solovyova & Vladimir Slivyak, "Race to the Bottom. Consequences of massive coal mining for the environment and public health of Kemerovo Region". Environmental Group Ecodefense, 2021, p. 4.

26 Trata-se do Bank of America e o Citi dos EUA, o Commerzbank da Alemanha, o Banco da China e cinco bancos russos: Alfa Bank, Gazprombank, Renaissance Capital, SberCIB e VTB Capital. Cf. Urgewald, Banktrack, "Commerzbank, Citi and Bank of America among banks issuing new deal for Russian coal giant SUEK just two month before COP26", 9/IX/2021.

27 Cf. "Coal Power Finance in High Impact Countries". Sustainable Energy for All & Climate Policy Initiative, IX/2021.

28 Cf. Energy Policy Tracker, "Track public money for energy in recovery packages", 7/IV/2021.

29 Cf. Doubing Back and Doubling Down. G20 scorecard on fossil fuel funding, IISD, Oil Change, Novembro de 2020: "G20 governments provided $584 billion1 annually (2017–2019 average) via direct budgetary transfers and tax expenditure, price support, public finance, and State-Owned Enterprises investment for the production and consumption of fossil fuels at home and abroad".

30 Cf. Ian Bremmer, "The Long Shadow of the Visible Hand". The Wall Street Journal, 22/V/2010: "the 13 largest energy companies on Earth, measured by the reserves they control, are now owned and operated by governments. Saudi Aramco, Gazprom (Russia), China National Petroleum Corp., National Iranian Oil Co., Petróleos de Venezuela, Petrobras (Brazil) and Petronas (Malaysia) are all larger than ExxonMobil, the largest of the multinationals. Collectively, multinational oil companies produce just 10% of the world's oil and gas reserves. State-owned companies now control more than 75% of all crude oil production".

31 Segue-se aqui a definição de "estatal" proposta por Richard Heede, do Climate Accountability Institute, empresas em que mais de 50% das cotas pertencem ou são controladas por um Estado. Cf. Richard Heede, Carbon Majors. Updating activity data, adding entities, & calculating emissions: A Training Manual. Climate Accountability Institute, 2019: "Many state-owned companies are partially owned by individual and institutional shareholders. These include Equinor, Petrobras, and Gazprom, and are considered state-owned if more than fifty percent of shares are controlled by the state. Equinor (formerly Statoil) is 67% owned by the Norwegian government, Petrobras is 64% owned by the government of Brazil, and Gazprom is 50.003% owned by the Russian Federation. In the coal sector, Coal India is 78% owned by the government".

32 Cf. OffShore, "Top ten oil and gas companies in 2020", 20/X/2020.

33 Cf. OffShore, cit., 14/V/2019.

34 Cf. "National Oil Companies and Climate Change". National Resource Governance Institute & International Institute for Sustainable Development (IISD), Seminário, 21/IV/2021: "National oil companies (NOCs) wield a major influence over the fight against climate change: they produce more than half of the world's oil and gas and are projected to spend almost $2 trillion on upstream projects over the next decade".

35 Cf. Amanda Morrow, "World's state-owned oil companies are 'betting on missing climate goals'". RFI, 10/II/2021.

36 Cf. Fiona Harvey, "Secretive national oil companies hold our climate in their hands". The Guardian, 9/X/2019.

37 Citado por Pierre Le Hir, "Réchauffement climatique: la bataille des 2 o C est presque perdue". Le Monde, 31/XII/2017.

38 Veja-se 2020 The Climate Turning Point

39 Cf. Opening of COP25, 2/XII/2019 Statement by IPCC Chair Hoesung Lee: "Our assessments show that climate stabilization implies that greenhouse gas emissions must start to peak from next year. But emissions are continuing to increase, with no sign of peaking soon".

40 Christiana Figueres, Hans Joachim Schellnhuber, Gail Whiteman, Johan Rockström, Anthony Hobley & Stefan Rahmstorf, "Three years to safeguard our climate". Nature, 29/VI/2017.

41 Cf. Gregg Marland, Tom Oda & Thomas A. Boden, "Per capita carbon emissions must fall to 1955 levels". Nature, 565, 7741, 2019, p. 567: "In 1977, when the global population was 4.23 billion, emissions per capita were 1.19 tonnes of carbon per person. By 2017, this had increased to 1.34 tonnes (the global population that year was 7.55 billion). So, decreasing total emissions to the 1977 figure will mean returning per capita emissions to those recorded for 1955".

42 Cf. Michael Mann, "Earth Will Cross the Climate Danger Threshold by 2036". Scientific American, 1/IV/2014.

43 Cf. Daniel Quiggin et al., "Climate Change RiskAssessment 2021". Chatham House, Setembro de 2021: "By 2040, the proportion of global cropland affected by severe drought – equivalent to that experienced in Central Europe in 2018 (50% yield reductions) – will likely rise to 32% each year, more than three times the historic average".

44 Cf. "Closing the gap. The impact of G20 commitments on limiting global temperature rise to 1.5 o C". WRI, Setembro de 2021.

45 Cf. Will Steffen et al., "Trajectories of the Earth System in the Anthropocene". PNAS, 6/VIII/2018.

Disponible en: **https://www.electrygasenergia.com/category/noticias/?cli_action=1635536594.543**

[YouTube® video de Minera Las Bambas] "Nuestra acciones frente al calentamiento global". Disponible en: https://www.youtube.com/watch?v=rWpEBOhX02o

[YouTube® video de Ministerio de Ambiente y Desarrollo Sostenible - Colombia] "Cambio climático - Reducción de Gases Efecto Invernadero en sector hidrocarburos y minería de carbón". Disponible en: https://www.youtube.com/watch?v=NOrC-5maNgg

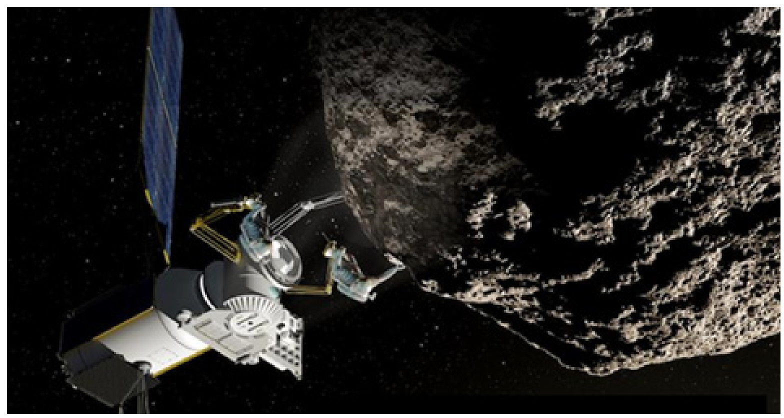
Derecho a la propiedad de los recursos naturales en el espacio

Valentina Wagner Gutiérrez[1]

Valentina Wagner G.

Han pasado más de 50 años desde la creación del Tratado del Espacio Ultraterrestre. Los debates del siglo XXI han estado marcados por los desafíos de esta nueva era. Entre estos desafíos se encuentra la minería, que hasta hace unos años parecía imposible. Este artículo examinará los posibles beneficios de la minería lunar como fuente de energía y el rápido interés de empresas privadas y naciones como Estados Unidos, Luxemburgo, Rusia, China e India. Reconocerá la necesidad de regular la minería antes del inicio de cualquier misión y apreciará los beneficios económicos que podría traer junto con las diferentes interpretaciones sobre la propiedad de los recursos naturales. A continuación, analizará más a fondo el concepto de *res communis* en el espacio ultraterrestre y el concepto de patrimonio común de la humanidad. Contempla los desafíos globales que incluye la regulación actual.

Conflictos y retos



El aprovechamiento de los recursos naturales espaciales como realidad en desarrollo. Reto a las geociencias (de la Tierra y Planetarias).

El calentamiento global, la crisis ambiental y la progresiva escasez de recursos naturales son elementos que crearán futuros conflictos entre las naciones. A pesar que la degradación ambiental es cada vez más evidente, que sus efectos han implicado cambios en los ecosistemas, hoy en día no hay forma real de mitigar los mismos.

¿Dónde encontramos una solución? Desde 1957, con el lanzamiento del satélite Sputnik 1, el interés de los Estados se desplaza al mítico y desconocido espacio ultraterrestre. Se contempló el espacio ultraterrestre, la Luna y los demás cuerpos celestes como posibles fuentes de energía útiles para la humanidad. Por lo tanto, puede estar albergando todos esos recursos necesarios para la subsistencia humana en la Tierra.

El derecho espacial surge después de la Segunda Guerra Mundial (1939-1945). La Tierra y el espacio aéreo en guerra y el espacio ultraterrestre emergen como un nuevo campo de poder. La comprensión de la magnitud de una guerra en el espacio ultraterrestre demuestra la necesidad de crear un conjunto común de normas para garantizar el uso pacífico y los beneficios para toda la humanidad (Seara 1961). Siendo esto así la creación del Tratado del Espacio Ultraterrestre de 1967 y el Tratado de la Luna de 1979.

Sólo han pasado 50 años desde que la humanidad comenzó a dejar una huella en el espacio. Los nuevos avances tecnológicos que crecen cada día, la posibilidad de extraer recursos naturales en el espacio parece estar acercándose rápidamente. No obstante, la regulación espacial actual es generalmente ambigua, imprecisa con poca práctica estatal que ha llevado a una gran controversia en asuntos

Palabras clave/Keywords/Palabras-chave:
Common Heritage of Humanity, Espacio Ultraterrestre, *Espaço Exterior,* Helio-3, *Hélio-3, Helium-3, Moon Treaty, Não Apropriação*, No Apropiación, *Non-Appropriation, Outer Space, Outer Space Treaty,* Patrimonio Común de la Humanidad, Patrimônio Mundial, *Tratado da Lua,* Tratado de la Luna, Tratado del Espacio Ultraterrestre, *Tratado do Espaço Exterior*.

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como la obligación de compartir los frutos de las empresas en el espacio y el título legal de los recursos extraídos (Smith, 1988).
La regulación de la alta mar y la Antártida, aunque no son perfectas, muestran un prototipo para las soluciones de los problemas espaciales con una posible solución para la obligación de compartir los frutos de las misiones en el espacio y el título legal de los recursos extraídos.

Al analizar la alta mar, la Antártida y el espacio ultraterrestre, es fundamental comprender que se trata de zonas designadas para el beneficio de la humanidad. En este sentido la designación de las áreas como res communis y luego transformadas a Patrimonio Común de la Humanidad es una protección a las áreas de la soberanía nacional. El concepto de Patrimonio Común de la Humanidad es uno que, como se ve tanto en el Tratado de la Luna como en la Tercera Convención de las Naciones Unidas sobre el Derecho del Mar, causó un gran problema entre las naciones, creando tasas de aprobación e implementación muy bajas.

En primer lugar, es vital comprender el concepto de res communis que se aplicó por primera vez en la Convención de Ginebra de 1958 sobre el Derecho del Mar y el Tratado del Espacio Ultraterrestre. La alta mar era res communis, lo que significaba posesión común. La posesión común no debe entenderse como propiedad. Significa que tanto los Estados como los individuos tienen derecho a utilizar res communis libremente siempre que no obstaculice los mismos derechos de los demás (Holmila, 2005). Esta parte se tradujo entonces en el Tratado del Espacio Ultraterrestre, que hizo del espacio ultraterrestre, la Luna y otros cuerpos celestes una posesión común de la humanidad. La diferencia entre el espacio ultraterrestre y la alta mar en relación con la res communis es que la Convención de Ginebra de 1958 sobre el Derecho del Mar muestra cómo los derechos de propiedad limitados pueden coexistir con las libertades en una zona de res communis. El artículo 2 otorga el derecho a pescar en aguas internacionales, permitiendo así al pescador la propiedad sobre sus capturas. Lo anterior reconoce que existe un derecho a pescar en alta mar que indica dos tipos de propiedad: i) un derecho limitado sobre los peces no capturados; y (ii) una propiedad sobre el pescado una vez capturado. Lo anterior muestra que existe una separación entre la apropiación de la superficie y los recursos ubicados en áreas res communis. Por ende, ninguna nación podría apropiarse de la alta mar, pero podría utilizar los recursos que se encuentran en su interior (Eckert, 1979).

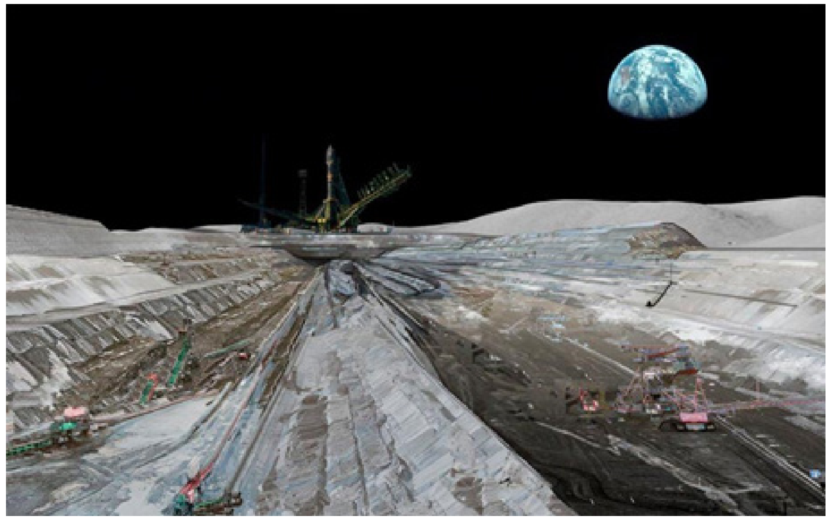
En cuanto al Tratado del Espacio Ultraterrestre, el artículo I creó controversia en cuanto a la forma en que los beneficios de la exploración espacial se distribuirían entre las naciones (COUPUS, 1966). Los redactores decidieron establecer el principio de la libertad de uso (COUPUS, 1966). Se garantiza la concesión de derechos de explotación para utilizar el espacio ultraterrestre, pero vale la pena señalar que esto sucedió hace 50 años, y el debate se centró en los posibles beneficios derivados de los satélites en lugar de la cuestión de la extracción de recursos naturales (Johnson, 2006).

El artículo II se había centrado en una restricción del derecho a utilizar el espacio y la no apropiación de este. Se declarará que la definición de no apropiación no determinaba de manera apreciable qué actividades entrarían en el ámbito del término uso y que la disposición debía estar abierta a nuevas mejoras en el texto. Por ende era imposible predecir cómo avanzaría la tecnología en referencia a la extracción de recursos lunares y advirtió que era demasiado prematuro crear una regulación para esa actividad. Siguiendo esta idea, vale la pena señalar que este Tratado del Espacio Ultraterrestre sólo regula las realidades de esa época, pero no tenía por objeto regular la posibilidad de lo que entonces era un futuro lejano.

Siendo así, incluso si el Tratado del Espacio Ultraterrestre sólo tuviera por objeto regular la realidad, se podría haber hecho una distinción entre la esfera de res communis y los recursos internos. La Convención de 1958 viene a demostrar que en 1967, cuando se creó el Tratado del Espacio Ultraterrestre, el derecho internacional permitió la distinción (Johnson, 2010). Por lo tanto, parece que los redactores del Tratado del Espacio Ultraterrestre podrían haber examinado las diferencias entre una res communis y sus recursos naturales muebles, pero esta distinción exacta no está en vigor. Sin embargo, para dar sentido jurídico a las disposiciones enunciadas en los artículos I y II, hay que hacer esa distinción. Así como la alta mar y el fondo marino están separados de sus recursos, que es decir, que se consideran como dominios diferentes lo mismo tiene que hacerse en el espacio. Esta falta de claridad en el Tratado del Espacio Ultraterrestre es una de las razones por las que es necesario un nuevo marco.

El concepto de res communis cambió al concepto de Patrimonio Común para la Humanidad con el Tratado sobre la Luna de 1979 y la Tercera Convención de las Naciones Unidas sobre el Derecho del Mar de 1982.

Como se mencionó anteriormente, no existe una sola definición del concepto de Patrimonio Común para la Humanidad. Sin embargo, existe una aceptación en la comunidad internacional



Recreación de explotación minera en la Luna de la Tierra.

de que significa "propiedad de todos y no apropiación por parte de cualquiera" (Ballah, 1982). También vale la pena señalar que, al igual que no existe una definición universal, la aplicación de este concepto debe aplicarse de manera diferente según el caso. Teniendo en cuenta estas cosas, no sería útil llegar a una sola definición del concepto (Holmila, 2005). El principio de no apropiación es quizás uno de los elementos clave de la reglamentación del mar, el espacio ultraterrestre y la Antártida. Lo primero que debe analizarse en este elemento es la inadmisibilidad e irreconocibilidad de las reclamaciones soberanas hechas en estas áreas. Esto es especialmente cierto en el fondo marino y el espacio.

Es importante señalar que hay una excepción a esta regla y es el caso de la Antártida. El Tratado Antártico de 1959 no anula las reclamaciones existentes, sino que las congela (Holmila, 2005). Sin embargo, estableció que no permitirá reclamos de soberanía y jurisdicción en el futuro.

El principio de no apropiación no prohíbe la explotación en la zona. Se refiere a la facilitación de la exploración de los fondos marinos y la propiedad de los recursos, ya que están sujetos al control internacional de la Autoridad Internacional de los Fondos Marinos. Además, esta exploración tiene que estar en consonancia con el resto del tratado.

Esta diferenciación no se hace en el Tratado de la Luna. El Tratado sobre la Luna establece que ni la superficie, ni el subsuelo, ni los recursos de la Luna, están sujetos a apropiación. Sin embargo, de la Tercera Convención de las Naciones Unidas sobre el Derecho del Mar se desprende que la separación entre el lecho marino y los recursos es vital. Porque la no apropiación del fondo marino no significa que los recursos no puedan ser propiedad. Como una cosa no excluye a la otra, significa que el fondo marino puede utilizarse sin apropiación. Por lo tanto, al crear la nueva regulación para la extracción de recursos naturales, la separación realizada en la Convención de las Naciones Unidas sobre el Derecho del Mar III debe tomarse como un prototipo.

Dado que no existe una definición universal del concepto de Patrimonio Común de la Humanidad, no hay una forma específica de compartir los beneficios obtenidos de la extracción de recursos naturales. Sin embargo, de conformidad con la Tercera Convención de las Naciones Unidas sobre el Derecho del Mar y el Tratado sobre la Luna, debería haber una distribución equitativa de los beneficios. No obstante, la forma en que esto debe hacerse varía dependiendo del régimen.

Al crear el nuevo marco para explotación del espacio, vale la pena señalar que la base del derecho espacial, el Tratado del Espacio Ultraterrestre, establece que los beneficios obtenidos de las actividades en el espacio deben compartirse con la humanidad. Adopta el enfoque amplio adoptado por la Tercera Convención de las Naciones Unidas sobre el Derecho del Mar. Por lo tanto, corresponde a los redactores decidir si los ejemplos tomados en los tratados exitosos de la Convención de las Naciones Unidas sobre el Derecho del Mar III y el Tratado del Espacio Ultraterrestre deben seguirse para el futuro de la minería lunar.

Peligros de la costumbre internacional

Hasta hoy no ha habido una misión para minería con el Tratado del Espacio Ultraterrestre. La tecnología para la minería lunar aún no está creada. Si esto es cierto, múltiples Estados (es decir, Rusia, Estados Unidos, Japón, China, India, entre otros) han mostrado iniciativas y establecido fechas para múltiples misiones exploratorias en la búsqueda de recursos. En el caso de que una nación o un privado extraigan con la actual regulación vaga y ambigua puede crear un precedente que será difícil de revertir.

Este precedente será difícil de revertir, ya que la firma y ratificación de un tratado internacional no es la única forma de crear un derecho internacional vinculante. La costumbre internacional es la creación de un conjunto de reglas formadas por la conducta repetitiva de las naciones que actúan con la creencia de que la ley les obliga a actuar en ese sentido (Rosenne, 1984). Esto significa que el derecho internacional consuetudinario abarca dos elementos: “1) la práctica internacional coherente y general de los Estados, y 2) la aceptación subjetiva de la práctica como derecho por la comunidad internacional (opinio juris)” (Kindred, 2000).

Teniendo en cuenta lo anterior, es vital referirse a la situación hipotética de que hay minería en la Luna y la recolección y producción de He-3 como fuente de energía es factible. Si hay varios Estados que minan en la Luna, podría crear una práctica reiterativa que construye el primer elemento del derecho internacional consuetudinario. El segundo elemento es la aceptación subjetiva por parte de la comunidad internacional. Para analizar este punto, hay que recordar el mayor problema de la ambigüedad de los tratados espaciales: no hay un entendimiento claro sobre el uso y la apropiación de los recursos y no hay una representación clara de cómo se compartirán los beneficios.

Dicho esto, actualmente existen legislaciones nacionales aprobadas y aceptadas que aclaran estos temas (Estados Unidos y Luxemburgo). El objetivo de estas legislaciones es aclarar esas ambigüedades, beneficiando a sus Estados y nacionales, afirmando que los recursos extraídos, pertenecen a los ciudadanos (en el caso de los Estados Unidos y Luxemburgo) y aquellos que poseen una oficina permanente en el país (en el caso específico de Luxemburgo) (Congreso de los Estados Unidos, 2015; Gobierno de Luxemburgo, 2017). Este precedente está empezando a crearse primero por la aceptación y aplicación de estas leyes en el sistema jurídico nacional tanto de los Estados Unidos como de Luxemburgo. Vale la pena señalar que más Estados internacionales están comenzando a reconocer este tema a medida que se han creado alianzas bajo la ley de Luxemburgo entre dicho gobierno y naciones como Japón, India y los Emiratos Árabes Unidos (Space Resources, 2017; Donoghue, 2018; Ahmed, 2019). Las acciones entre las naciones mencionadas pueden llevar a la interpretación de que los elementos de dichas leyes son correctos, creando así una aceptación subjetiva de la ley más allá de la jurisdicción nacional de Luxemburgo.

Lo anterior muestra un ejemplo de que las prácticas reiterativas y la aceptación subjetiva pueden crear un precedente vinculante y convertirse en un tratado. En vista de ello, es crucial decir que si la minería se produce sin un marco adecuado diseñado para regular la minería de los recursos naturales en la Luna, existe la posibilidad de que la creación del marco sea difícil. Una vez que comienza la minería existe la posibilidad de que las acciones tomadas sin regulación se conviertan en reiterativas y aceptadas, creando así una ley internacional vinculante. Todo esto para decir que si la minería ocurre sin regulación, entonces será aún más difícil regular y desacreditar las prácticas reiterativas.

Conclusiones

La comparación de las reglamentaciones del espacio ultraterrestre con las reglamentaciones de la alta mar, los fondos marinos y la Antártida muestra los elementos de que carece el derecho espacial para la extracción de recursos naturales. Estos tratados pueden estar vinculados en el hecho de que los recursos naturales están más allá de un control territorial de las naciones, para llegar a ellos se necesita una tecnología específica, y las exploraciones deben hacerse siempre protegiendo el medio ambiente (Heim, 1990).

En vista del análisis, se puede concluir que no existe una diferenciación clara entre los recursos naturales y el terreno espacial y que no existe un mecanismo claro para controlar o compartir los beneficios extraídos.

Por lo tanto, es tentador preguntarse, ¿quién tendría la propiedad de dichos recursos?

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Environment
Ambiente
Meio ambiente

Proposals for artisanal and small-scale mining (ASM) in Venezuelan Guiana based on the experience of the last 30 years

Propuestas para la minería artesanal y de pequeña escala (MAPE) en la Guayana venezolana con base en la experiencia de los últimos 30 años

Propostas de mineração artesanal e de pequena escala (MAPE) na Guiana venezuelana com base na experiência dos últimos 30 anos

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Recibido: 6-10-21; Aprobado: 16-11-21

Abstract

Aimed to do a bit to the improvement that the artisanal and small-scale mining (ASM) sub-sector will ever have to have, it has been decided to start from the proposals made by Quaglia & Barbetta (1991) and consider other proposals made in Venezuela and the rest of the world in the last 30 years, as well as considering the experience that the authors have had, and finally making the proposals that are exhibited in this paper, which consider a stage of transition and another one of standard performance aimed at promoting ASM evolution as a strategy so that it ceases to be a costly problem for the environment, the society and the State and becomes an engine of sustainable socio-economic.

Resumen

Con la motivación de aportar un granito de arena a la mejora que tendrá que tener el subsector de la minería artesanal y de pequeña escala (MAPE), se ha decidido partir de las propuestas de Quaglia & Barbetta (1991) y considerar otras propuestas realizadas en Venezuela y el resto del mundo en los últimos 30 años, además de considerar la experiencia que han tenido los autores, y finalmente realizar las propuestas que se exhiben en este trabajo, las cuales consideran una etapa de transición y otra de desempeño estándar orientada a promover la evolución de la MAPE como estrategia para que deje de ser un problema costoso para el medio ambiente, la sociedad y el Estado y se convierta en un motor de desarrollo socioeconómico sostenible.

Resumo

Com a motivação de contribuir com um grão de areia para a melhoria que o subsetor da mineração artesanal e de pequena escala (ASM) deverá ter, decidiu-se partir das propostas de Quaglia & Barbetta (1991) e considerar outras propostas apresentadas na Venezuela e no resto do mundo nos últimos 30 anos, além de considerar a experiência que os autores tiveram, e finalmente fazer as propostas que se expõem neste trabalho, que consideram uma etapa de transição e outra de desempenho padrão a que se almeja promover a evolução da ASM como estratégia para que ela deixe de ser um problema oneroso para o meio ambiente, a sociedade e o Estado e passe a ser um motor de desenvolvimento socioeconômico sustentável.

Palabras clave/Keywords/Palabras-chave:
Artesanal, artisanal, ASM, environmental recovery, hydraulic monitors, i*nversión social, investimento social, MAPE, mercurio, mercúrio,* mercury, *mineração, minería,* mining, *monitores hidráulicos, pequena escala, pequeña escala, recuperação ambiental, recuperación ambiental,* small scale, social investment.

Introduction

According to Solidaridad (2020), approximately 100 million artisanal miners exist globally (Abulnaga (2021) agrees on this), and artisanal mining contributes an average of 60% of many countries' supply of precious minerals, while on the other hand, an average of 70 to 80 percent of small-scale miners are informal, additionally, EPA (n.d.) states that 20% of the gold produced in the world comes from ASM, which releases 400 t of elemental mercury into the atmosphere (Es-

[YouTube® video] "Por qué es importante la minería de oro artesanal y en pequeña escala responsable, para las personas y el medio ambiente". Retrieved from: https://www.youtube.com/watch?v=YkFJ1GzvhAI

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daile & Chalker (2018) stated that ASM is the largest source of mercury pollution in the world, releasing 1,000 t/y that includes vaporized mercury), while the OECD (2019) cited by World Bank (2020) asserted that ASM is responsible for the production of 25% of the world's diamonds, 20% of gold, 80% of sapphires and 18% to 30% of the cobalt.

World Bank (2020) also argues that ASM is the main source of employment for 44.75 million people in 80 countries; citing themselves from 2019, stated that the indirect employment generated by ASM worldwide could be 134 or 269 million people, depending on the multiplier used.

Abulnaga (2021) states that ASM is important for countries such as Morocco, Bolivia, South Africa, and Sudan where it is actively promoted by governments while revealing that in South Africa 30 million people depend indirectly on them mining levels, and in Sudan, around 1 million people depend directly on the activity.

Hilson (2002) argued that despite the potential for benefits that ASM can bring to the rural world and developing countries, it accumulates significant environmental and socio-economic impacts.

According to Olivo (2007), by 2007 there were around 50 thousand artisanal and small-scale miners in Bolívar state, additionally, she cited the Cámara Minera de Venezuela (CMV), which had reported that by the end of 2003, there were produced about 25 t of gold, of which around 15 t were produced by these miners, formally or not, the CMV also stated that for that same date there were between 26 and 30 thousand of these miners in the gold sector; on the other hand, citing the Ministerio de Energía y Minas, it was found that between 2001 and 2004 there was an investment in small scale gold mining of less than 29 million US dollars.

Olivo also stated that the tax evasion of artisanal and small-scale miners was 35% and that, while the Corporación Venezolana de Guayana administered this sub-sector, between 1994 and 1999, it contributed taxes to the treasury for 1,429 million bolivars while the concessionaires contributed 2,205.3 million; she also pointed out that diamond production has traditionally been carried out by this scale of mining.

Sánchez (2021) has stated that currently, due to the reduction in oil production and income from this sector, mining in Bolívar state represents a source of income and employment, while socio-ecological impacts are expected due to the degradation of soils and hydric structures.

GIATOC (2016) as cited in De Souza (2019) revealed that Venezuela along with Peru are considered the largest illegal gold producing countries in the world. De Souza, affirms that the ranking of illegal gold production is led by Venezuela with 90%, followed by Colombia with 80%, Ecuador with 77%, and Bolivia and Peru with around 30%.

It is worth to subscribe what was expressed by Labonne (2014) who argued that ASM exists due to poverty and operates in rural areas that are normally poor, but this mining sub-sector has the potential to finance the desired reduction of rural poverty that costs so many resources to State, in such a way that world governments have acted with inconsistency because with adequate policies ASM can cease to be a problem to become a very important part of the solution.

Overview. Climate, Vegetation & Soils

Regarding the climate of the study area, it is characterized by presenting a tropical rainy climate, where the total mean annual precipitation is approximately 1,800 mm, registering rainfall greater than 3,000 mm per year, for the entire area. Approximately 64% of the average annual total precipitation falls between May and August. Average annual temperatures vary between 25.7 and 23.4 °C. for altitudes between 100 and 500 m above sea level, and between 23.4 and 20.6 °C for those heights between 100 and 1,000 m above sea level. Concerning the vegetation, there are plant formations adapted to the humidity conditions, temperature, soils, and physiography. According to the Holdridge classification from 1967, the study area belongs to the premontane very humid forest life zone. They represent eventual virgin forests with species whose heights are between 25 and 50 m. Structurally there are 3 defined strata, which are comprised between 0 and 5 m for grasslands, heights between 5 and 12 m with co-dominated species in heliotic competition to reach the upper strata and the upper arboreal stratum with a height greater than 12 m integrated by dominant species forming the typical stratification of tropical forests. With regard to soils, the area is formed by strata with a moderate degree of evolution, which keep close relationships with the lithological substrate and with the different landscapes. The following types of soils are found: Ultisols, Entisols, and Inceptisols. The lithological substrate is closely related to the geology of the study area, which is included in the geological province of Pastora (2,000 to 2,700 million years). The Pastora supergroup group constitutes green rock belts of special interest in this study where the geological Supamo complex is located, whose lithology consists of sodium granite, paragneiss, migmatites, granodiorites, and pegmatite. Finally, recent units are distinguished formed by alluviums containing sands, silts, clays, quartz gravel, and fragments of volcanic rocks. This area is characterized in its entirety by a flat peneplain over metamorphic igneous rocks made up of eroded remains of basic rocks, sandstones from the Roraima group, and the rest of the rocks of a green rock belt. Granite intrusions into the Green Belts, have peripherally originated the location of gold veins of great economic value. The weathering and consequent erosion of their materials have distributed gold alluvium of very high tenor throughout the area and in the major river's beds.

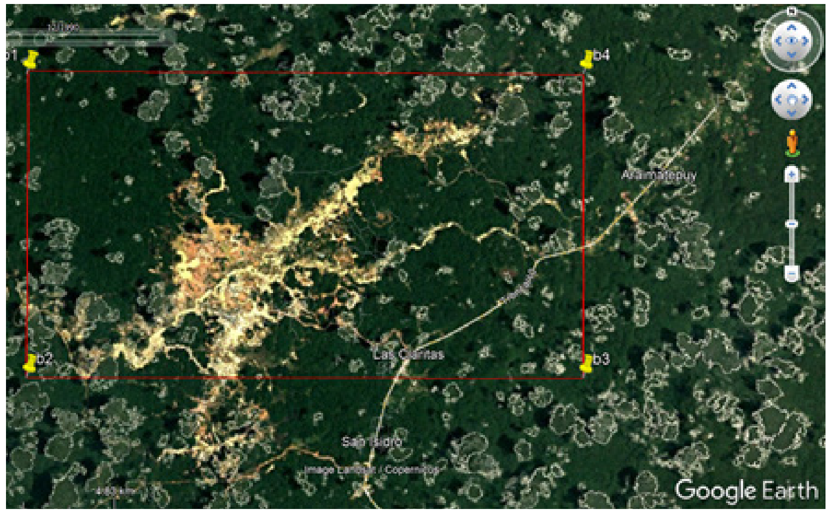

Figure 1a. Quaglia & Barbetta (1991) study area in December 1990. Obtained from Google Earth®

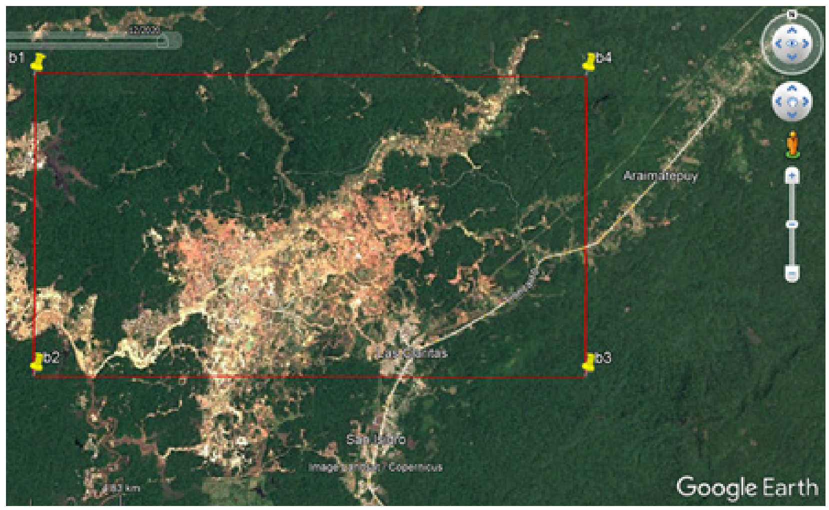

Figure 1b. Quaglia & Barbetta (1991) study area in December 2020. Obtained from Google Earth®

Background

Quaglia & Barbetta (1991) carried out a study and evaluation of the environmental deterioration caused by gold mining activity in the area of Km 88 (San Isidro) in Bolívar state, and they focused on the exploitation systems used by small-scale miners and the impact that they caused on the environment, specifically vegetation, soil and water, they also evaluated experiences in the recovery of intervened areas and suggested a mining-environmental plan to mitigate damage to nature and achieve harmonization of mining with the environment.

It is evident that the recommendations made by these authors were not implemented or perhaps were implemented only for a time; it is evident, at present, that the magnitude of the damage to the environment in the study area for which they made their recommendations has increased significantly as can be seen in the Google Earth ® images shown in figure 1a, and 1b.

The available scientific literature exhibits dozens of papers that abound in damage diagnoses without proposing feasible solutions, however, a few authors have transcended the eternal diagnosis and have made proposals to contribute to the solution of the problem linked to ASM, above the classic: "stop mining", some of such papers are exposed below:

Herrero & Rivas (2001) reported the results of an agro-conservation strategy that they carried out in two localities affected by ASM with the purpose, not only, of achieving environmental recovery but also socio-economic-environmental sustainability-oriented toward the post-mining, preparing communities to practice the conservationist agriculture.

La Barbera (2005) carried out a mining-environmental diagnosis in a small-scale mining project in the Hoja de Lata area, Sifontes municipality of Bolívar state, having detected degradation of the terrestrial and aquatic ecosystems due to the discharges of solid waste In suspension, additionally, it made a series of technical proposals to improve mining activities in the sector and reduce impacts on the environment.

Adams, et al. (2007), utilized phospho-gypsum, which is the most important residue from the phosphate fertilizer industry, to recover damaged soils from small-scale and artisanal mining in Venezuela. The results of their research were that phospho-gypsum can immobilize mercury, as kaolin or hematite do. Additionally, the use of phospho-gypsum and sulfate-reducing bacteria together will allow the integral rehabilitation of the devastated areas, but it is necessary to know the bacterial microbiota of soil before the inoculation with any bacteria.

Díaz & Elcoro (2009) determined, between 1992 and 1993, at five ASM areas in Bolívar state, which are the autochthonous species that allow the areas affected by mining to be revegetated, finding that they are common to almost all the mining areas observed, such species are: cyperus odoratus, c. luzulae, Fuirena umbellata, Pityrogramma calomelanos, trema micrantha, and Phytolacca rivinoides, on the other hand, determined that on the surface of the mining tails, the observed species adapt to the poverty of substrate and lack of humidity but as the original soils are normally left towards half or lower, in the tail deposits, observed higher species richness.

González (2013) carried out a characterization of the existing tailing in the IA-12 plot of Bizkaitarra, having established that the recovery of gold was viable, recommending subsequent studies for the use of Ti, Ni and Cr, while recommending that it be coarse material, above 3 mm in diameter, could be used as construction aggregate, for filling, sediment traps, dyke-like structures to control the deposition of tails generated by gold production.

Lozada (2017) stated that ASM could not be eliminated given its socio-economic component, at the same time he recommended that the use of hydraulic monitors and ponds should not be allowed and that it should be eliminated the use of mercury and expressed that artisanal mining and industrial underground mining are which least environmental impacts causes.

Some of the contributions which have been made for getting better ASM from outside Venezuela are:

Chaparro (2000) argued that about miners, the governments of the region, that is, Latin America, should act strictly to safeguard society from people who, within the world of informal mining, act in an uncivilized way resisting, one way or another, for mining to be conducted on a sustainable path, additionally, it stated that policies and instruments should be implemented that would make the exercise of uncontrolled informal mining more difficult, less remunerative and riskier, applying fines, confiscating the produced mineral, and punishing those who buy what they produce.

Hilson (2002a) stated that in Ghana, small-scale mining was an important contributor to national gold production, generating foreign exchange and employment, while mercury pollution and land degradation had been increasing, and established that improvements in the sector would be achieved if the Ghanaian Minerals Commission received help from the government, and academic units, if specific environmental strategies would be designed for the sector, a concerted effort for geological prospecting in search of possible deposits suitable for small-scale mining should be made, a mercury study should be carried out, and a retort program should be implemented.

Hilson (2002b) recommended that governments should begin to promote the reduction of environmental impacts and an increase in the quality of life in the world of miners, which could be possible by formalizing the sector, improving environmental management, and the needs of individual miners.

IIED & WBCSD (2002) proposed that ASM, due to the complexity of its problems, should be oriented to improve its contribution to sustainable development through a coordinated effort that involves all levels of government, communities, and employers, but the proposal contemplated sufficient flexibility to adapt to the various particular conditions, they also recommended that miners should be made aware of the negative impacts they cause and they must be invited to take measures to minimize them, highlights among others proposals that research institutions should focus on finding viable solutions to face the various problems diagnosed in ASM.

Gunson & Veiga (2004) regarding artisanal mining in China, recommended that instead of continuing with the Central Government practice of trying to close mines, the use of appropriate technologies should be regulated, trained, and promoted, emphasizing approaches integrated and sustainable for artisanal mining communities. These authors made more recommendations, among which it stands out that to reduce mercury consumption, centrifugal concentrators should be incorporated since in China only a few have done so, they also warned that carrying out a total ban on mercury would only lead to its use clandestinely and that the post-mercury cyanidation practice should be eliminated as this achieve greater solubility of mercury in tailing.

Romero et al. (2005) made recommendations for the performance of ASM based on social, governmental, technological, and economic aspects.

To restore areas impacted by ASM, Peixoto, and Perdigão (2006) proposed, prior mineralogical characterization and granulochemical analysis of the materials, the use of a Knelson concentrator and flotation to recover mercury and residual gold, having obtained a recovery of gold of 83.61% and mercury of 41.14%, highlighting that mercury with a concentration of less than 1.50 ppm remains at the bottom of the process, in such a way that this resulting material can return to the environment without generating any risk.

Spiegel & Veigas (2006) stated that despite the importance of ASM (considering the benefits for obtaining income for millions of people in the world), it generates severe negative impacts; revealed that misuse of mercury impacted the environment with 1,000 tons per year despite the existence of technologies that can substitute the use of mercury and make the operation more profitable, additionally, they proposed the competition of multidisciplinary teams that could guarantee satisfactory results with long-term positive effects, they also recommended that the best help could be obtained in initiatives from "bottom-up", that is, with the participation of governments, communities and miners, rather than options in which solutions are sought from the State or what is also called "top to bottom".

Aramburú et al. (2010) carried out a study to recover with clean technology, the mercury and gold from tailings generated in amalgamation processes, having determined that by doing a preconcentration with a Falcon concentrator and that the sample has been ground to have a granulometry of 77.89% -200 mesh, followed by cyanidation, it was possible to recover 33.82% of mercury but 66.18% remained in the tailing of this process, while it was possible to recover 97.56% of gold and 2.4% remained in tailing.

Amankwah et al. (2010) conducted direct casting tests in Tarkwa, Bolgatanga, and Bonte, Republic of Ghana, as a technique to replace amalgamation; the tests carried out in the field, using a locally manufactured furnace, allowed an average recovery of 98.3% of gold, while with mercury, 88% was recovered.

Neiva de Souza (2010) has stated that Brazilian regulations for ASM had not been effective, which is why he made recommendations to organize miners and give them adequate access to training, technical assistance, and technology, on the other hand, his work was carried out in the Tapajos region in the Brazilian Amazon where the main impacts caused by ASM are mercury pollution, water sedimentation, and deforestation, highlighting that the uncontrolled use of cyanide has increased risks to health and the environment. The author calculated that annually 6 million tons of sediments are generated that end up in the waterways, to combat this impact, it was implemented to fill the existing pits, produced by abandoned exploitations, with sediments from new exploitations, in other cases, triple barriers made of palm leaves were used, which were efficient to retain sediments.

Neiva de Souza argues that "it is easier to convince miners that reforestation is not only an environmental activity, but a profitable business that involves wood, fruits, seeds, and vegetable oil. Miners are more motivated by economic approaches than by environmental appeals.", in such a way that it was convinced miners to re-vegetating some refilled pits, and stated that in "Garimpo Canaan, the owner expected that his mahogany plantation would generate future gross income of US$ 3,200/ha/year." He also assured that "miners adopt environmental programs if they are associated with technical solutions that improve gold recovery or reduce costs, which in any case represents economic gains for them."

Additionally, Neiva de Souza recommended the intensive cyanidation of concentrates in a ball mill, since the amount of material to be treated with cyanide, compared to the leaching traditionally used by miners, is up to 700 times lower due to the previous gravimetric concentration, also recommended that residual cyanide be treated with bleach or peroxide after it has undergone natural degradation.

Based on factual evidence, got in the municipalities of Tadó y Condoto of Chocó Department in Colombia, Álvarez (2011), established that it was a priority to provide comprehensive technical assistance to stimulate miners in entrepreneurship, associativity, strengthening safety in their operations and occupational health, also asserted that the formalization of ASM would be possible with the coordinated effort of the communities, the State and the institutions.

Zolnikov (2012) stated that the evidence revealed the need for combined efforts to implement and maintain a lasting change, he also asserted that an adequate solution required government support, the knowledge obtained through risk assessment, the recognition of the impact of the buyer through successful Fair Trade gold labeling and education of miners, healthcare workers and locals within the hazardous area of mercury exposure; she argued that by using marketing, gradual changes could be achieved.

Díaz (2013) proposed, for the treatment of acid mine drainage generated in the Cascabel mine in Marmato, Colombia, but that can be extrapolated, according to her, to other extractions in the locality, the use of a lagoon that would receive the drainage generated in the operations and that would allow sedimentation, to the overflow of that lagoon, he has proposed that caustic soda be applied in a concentration of 0.6 ml of 1 molar solution of sodium hydroxide for each liter of acid mine drainage solution and subsequently the use of a filter bed built with anthracite, all of which guarantees, according to the tests carried out, that the pH rises to between 6 and 8, however, although a decrease in the concentrations of heavy metals was achieved, it was not achieved acceptable levels, according to the standards, that is why these waters should not be returned to natural channels in this conditions.

García et al. (2015) reported a successful case of mercury reduction in mining municipalities of Antioquia, Colombia, thanks to an alliance between the United Nations Industrial Development Organization (UNIDO), the government of Antioquia, the National University of Colombia, and the University of British Columbia, with the valuable collaboration of the company Gran Colombia Gold; the result of this experience between 2010 and 2013 led to a 43% reduction in the mercury used in the implementation sites of the cleaner methods that were taught and carried out and also achieved a reduction of mercury losses by 63%.

Adu-Gyamfi et al. (2016) reported that periodic environmental education efforts have been made trying to sensitize artisanal miners from Prestea, Ghana, about the environmental impacts and risks of the activity, but only weak results have been achieved with this measure, in such a way that they recommended that legislation be enacted to regulate the sites where mining and processing could take place.

Luna & Soto (2016) studied 5 mines in Colombia, of which 4 exploited alluviums and one extracted mineral from veins, and determined that due to the use of mercury there was a greater impact on water and air and a lower proportion of impact on the ground; sampling carried out in water showed 1.76 µg/l, sampling in the air up to 3,201.57 ng/m3 and in soils between 1,183.62 µg/kg and 1,949.93 µg/kg. These authors proposed that to avoid the use of mercury, in the case of the alluvial mines they studied, they should use Z-shaped sluice boxes, trommel, jig, and batea to process the final concentrate; in the case of the vein mine, they proposed primary crushing with jaws, secondary crushing with a ball mill, tertiary crushing with a barrel mill, trommel classification, concentration with a vibrating table and/or jig, then with a centrifugal concentrator, stirring cyanidation, after, gold recovery by Merril Crowe and finally smelting.

Pantoja & Pantoja (2016) analyzed the social, political, economic, technological, and environmental conditions of artisanal and small-scale gold mining in Colombia and suggested the structuring of a comprehensive public policy for the sustainable and responsible development of this scale of mining through the implementation of processes for its formalization as well as for the access to less impactful technologies of the environment, and the improvement of the quality of life of the miners and their communities.

Zamora et al. (2017) recommended the sustainable development of small mining in Bolivia in which, among other aspects, they considered technical, environmental, and social aspects, they also recommended that research be carried out in clean technologies for this scale of mining and that the State should obtain international collaboration to support this scale of mining.

Aren da Silva et al. (2018), carried out a review of methods for recovery of areas affected by ASM, having verified that there are methods that are costly and ineffective, they also detected that there are very few long-term evaluative studies, which they considered essential In order to improve in this type of activities, they also considered that the task could be carried out with materials present in the place obtainable at a lower cost, they considered the slope of the slopes and the drainage system very relevant, among others, asserting that The original soil is very important for the environmental recovery phase in such a way that it must be properly disposed of before starting the exploitation, on the other hand, they recommend that research lines should be developed that lead to determining the species that are more efficient in the recovery of each place and case at the lowest costs possible, they emphasize that the follow-up is very important because what recommends the Ecosystem/Landscape Functional Analysis (EFA) be used for such purposes; They emphasized that the planning of recovery activities recommended be carried out before starting operations.

Gomes (2021) carried out work for the use of tailing from small-scale gold mining in the municipality of Peixoto de Azevedo, in Mato Grosso, Brazil to make soil-cement hollow bricks. The experiments were positive based on the Brazilian standard NBR 8491; she also performed the calculation of the thermal capacity, the thermal delay, and the solar factor and compared them with the standards NBR 15575-4 and NBR 15220 for the bio-climatic zone of the study area, having obtained that the results are acceptable according to the first standard but not concerning the second, however, the author proposes that with a clear paint coat or coating the thermal retardation can be increased.

Villachica et al. (n. d.), have stated that in some countries an attempt has been made to ban the use of mercury or high taxes have been applied, resulting in an increase of up to 5 times in the price of mercury, but the reduction in the use of this substance has not been achieved, and much less the pollution that it generates because the miner uses it to survive, in such a way that they suggest an alternative that in their opinion is easy for miners to use and can eliminates the use of mercury, having obtained, in the tests they carried out, gold recoveries 20% higher than the traditional ones, but it should be noted that this proposal is replicable with the same results if the characteristics of the material to be processed are similar to those of the area where the tests were carried out in Puno, Perú, where, among other characteristics, heavy minerals are mostly magnetic or paramagnetic, in such a way that they recommend magnetic separation as a first step, using high intensity magnets that are easily obtained in the markets so that the acquisition price is more feasible for miners and assert that such magnets can be applied manually by any miner; the tests were carried out with neodymium magnets, achieving the elimination of 85% of the weight of the gold material. These authors recommend that, after this stage, the miners should move their material to a place that meets the necessary technical characteristics, where it can be processed with chemicals to obtain the mineral and sell it. They recommend direct leaching of the concentrate, dissolution with aqua regia, dissolution with partner cyanide, dissolution with other reagents, direct smelting, among others, it should be noted that the proposal contemplates recycling and regeneration systems for toxic reagents, and the production of reagents based on non-toxic materials that can be transported and handled without risk.

Km 88 sector. Extraction of gold. 30 years ago

For this work, it is good to establish that the current classification of ASM is different from the one used by Quaglia & Barbetta (1991), that small mining referred to, is the current ASM and not the small industrial mining carried out by Junior companies, the key difference is that in the ASM no geological reserves are known nor has the existence of any ore been determined, on the understanding that ore is a mineral deposit known in location, shape, weight, and quality and that it has been shown that it can be profitably mined. The normal thing is that the ASM undertakes operations like someone who plays the lottery or in a casino, trying to produce in places where the information available is very imprecise.

While small and large industrial mining can only be possible if reserves have been determined, and it has been shown that an ore exists, in such a way that the intervened areas are precisely those required to carry out the project, while in the case of the ASM, areas are usually impacted in which there is no mineral or the one that is found is insufficient to pay the costs incurred.

On the other hand, it is appropriate to point out that the ASM has no real possibilities of undertaking scientific geological explorations such as those required given the enormous investments required and the very high failure rate that accompany this activity, which is the riskiest of the entire mining industry.

Based on the above, the small mining that was studied 30 years ago was made up of those who operated with hydraulic monitors and those who used mechanization, and none of them had proven reserves.

Exploration is the first and most important stage in the discovery of economically profitable mineral deposits. Generally, it consists of geological, geochemical and geophysical prospecting. Unfortunately, this does not actually occur in the studied area. There is a strong lack of a systematic exploration, but rather to an empirical and somewhat improvised procedure.

The exploitation methods used in the study area were mainly characterized for the most part by the use of hydraulic monitors. To remove and transport both the overburden and mineralized material, the hydraulic method involved the use of water pumps, gravel pumps, sluices, pipes, high-pressure hoses, etcetera. Once the mineralized material has been removed, it's transported through a hydraulic system using gravel pumps and sluices, then processed by concentration methods.

The activity begins with the clearing or deforestation of the preselected area, using blades, chainsaws, and even the hydraulic power of the monitors (powered by water pumps). In this process, the vegetal layer or organic horizon is removed, in addition to the sterile overburden and mineralized horizon. The latter will be processed through a concentration system. While the sterile overburden is sent to sedimentation ponds, old exploitation fronts, or simply to watercourses. Generally, these deposits are defined as colluvial-alluvial deposits. The exploitation or removal of the gold-bearing material is carried out using hydraulic monitors. The pulp made up of water from the hydraulic monitors and the auriferous material removed by them is transported by gravity to the sink or waterhole, from where it is transported by gravel pumps through pipes to the concentration system, starting with the sluice which has an inclination that varies between 12° and 15°, generally 80 cm wide and 7 m long. The material or pulp passes over the sluice carpet, where the gold particles are trapped. The rest of the processed material, also known as "tailing", is piled up for the filling of the old exploitation fronts, or simply discharged to the water bodies washed and deposited by the river along its course. The concentrate settled in the sluice carpet was collected in a metal box and then with the help of a pan was amalgamated and separated from the black sands and other impurities. Once the amalgam (gold + mercury) was separated, it was burned to obtain metallic gold. Since in this separation process the mercury was released in the form of gas, it was carried out in the laboratory using a retort, where the amalgam was introduced, and it was subjected to heating until reaching the melting temperature so that the separation took place and metallic gold was obtained, and the mercury became vapor, which was conducted by a hose to a container with cool water to condense part of it and recover a good amount of the mercury used. The rest was escaped into the atmosphere. Metallic gold was subjected to a smelting process for refining, introducing it in a stove or furnace. Subsequently, the molten gold was emptied into a mold, obtaining gold bars. (Figure 2).

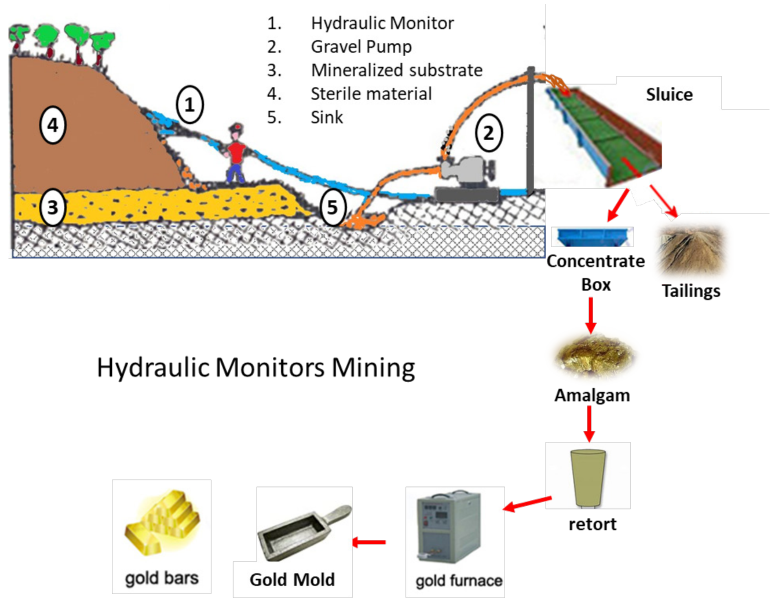

Figure 2. Hydraulic Monitors Surface Mining. (Modified from Quaglia & Barbetta, 1991).

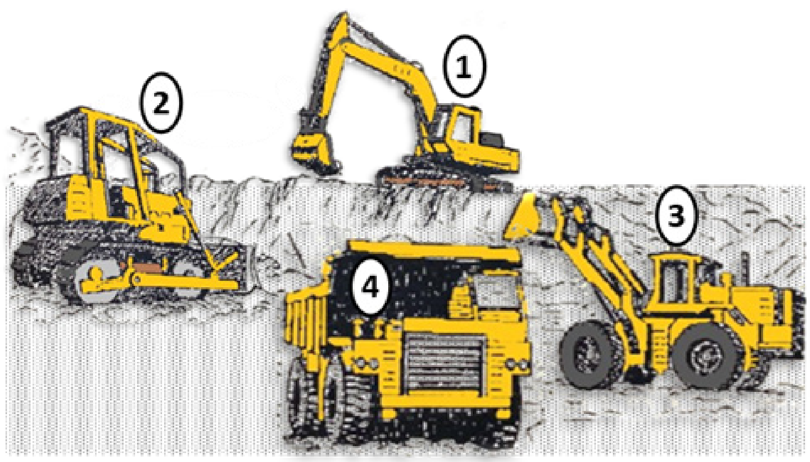

Figure 3. Heavy equipment used in the mechanized mining method. (Quaglia & Barbetta, 1991).

The mechanized system was also found, and to a lesser degree the rudimentary or manual method. This was due to various factors, such as technological conditions, economics, the characteristics of the deposit, and the legislation among others. The mechanized method included the use of heavy and electromechanical equipment, such as tractors, mechanical shovels, front loaders backhoes, dumper trucks, etc. This equipment and tractors were used for the different steps when removing and transporting soil and subsoil material: 1.- Excavation, 2.- Stacking or piling, 3.- Loading, and 4.- Transportation. (Figure 3).

Usually, this type of mechanized mining included in the small-scale mining was supported by a pilot plant which consisted of a trommel, "Knelson" concentrators, vibrating tables, mills, amalgamating drums. This equipment allowed making estimates and projections for short and medium-term operations. It was possible to determine in a certain way the amount of mineralized material (Tenor). Consequently, control of the efficiency of the processing equipment and concentration could be achieved, allowing to determine the failures or deficiencies in the system through the periodic sampling of the material that was processed in such a way the concentration process could be optimized. The exploration phase was carried out through pits and trenches planned in advanced phases, which allowed determining the areas to be exploited. Once the samples have been tested in the pilot plant, the exploitation phase was carried out in a mechanized way. The removal and stacking of the material were carried out using tractors. It should be noted that the gold-bearing material, in this case, was of the colluvial type. This material was loaded in dumper trucks by front loaders and transported to the plant. The material was discharged into a hopper where it was classified by a vibrating screen separating the thicknesses that correspond to a diameter greater than 2.5 in and stacking them as tailings. Material less than 2.5" in diameter was taken to a trommel via conveyor belt, where it was de-muddied and re-sorted. In such a way that any material less than 1/4-inch falls through a chute to a jig battery or washing machines where the heavier material goes to the bottom and the light comes out at the top as tails. The retained material in the jigs was conducted through a pipe to "Knelson" concentrators to obtain a concentrate, which consists of gold and black sands for the most part, and mercury if it has been used in the trommel. Gold or amalgam was separated from the black sands using spirals and, in case the volume of concentrate was not very large, it simply uses a pan. The black sands that were obtained in the spiral and the pan were subjected to grinding in a ball mill to then introduce them in an amalgamating drum, so they can be reprocessed again. The rest of the tails that were generated in the different phases of the concentration stage were stacked for later. Getting refined gold was similar to the process described above in the hydraulic monitors mining. (Figure 4).

In the artisanal sub-scale, also known as the "manual method", the miner has been using traditional tools such as the pick, the shovel, and the pan. In most operations, as known, mercury was used for the recovery of gold. Especially in the capture of fine particles, later, this alloy of gold and mercury, also known as "Amalgam", was burned for its separation; the gold remains free and the mercury evaporates. In this type of activity, the miner, who has been using the so-called manual method, has been characterized by being nomadic in his activity, and by using rudimentary equipment such as the pick, shovel, bars and pans or trays primarily, where the pan has been used as a concentrator and the rest of the equipment for the removal of the material. Generally, in this method, the miner has been established himself in places where the existence of gold has already been determined. Therefore, the exploration phase has been practically ignored or has been carried out briefly. This activity has been carried out mainly on the banks of rivers, streams, and stagnant waters as a result of previous mining activities. The damage that this type of activity causes to the environment is minimal; it is not the same case with the miner, due to the continuous exposure that it has been having to the toxic element, mercury; both, in the concentration stage and in the recovery stage, where practically a large part of the mercury gases have been inhaled by him without taking the necessary precautions. This method additionally requires that the miner spend most of the time with half of his body submerged in water. In the case of stagnant waters, the environment is conducive to the proliferation of insects that transmit diseases already known as marsh fever (Paludism) and malaria, among others. (Figure 5).

Environmental deterioration

In the development of mining activity, damages to the environment are generated in different magnitudes and ways. Problems of deforestation, destruction of the vegetation layer, soils degradation, contamination and alteration of water bodies, aquatic and terrestrial habitats, and problems in the social, and health area due to the miner's way of life and uncontrolled use of mercury. Figure 6.

In the case of vegetation, deforestation is unavoidable, since it is a stage that necessarily must clear the area that has been designated for exploitation. What is questionable in this case, is the irrational way how this stage was carried out. Many times, destroying green areas unnecessarily. This is a consequence of improvisation and lack of implementation of a work methodology where the areas of interest to be exploited are knowledgeably determined. Deforestation is carried out at ground level using machinery and even the hydraulic power of the monitors. The

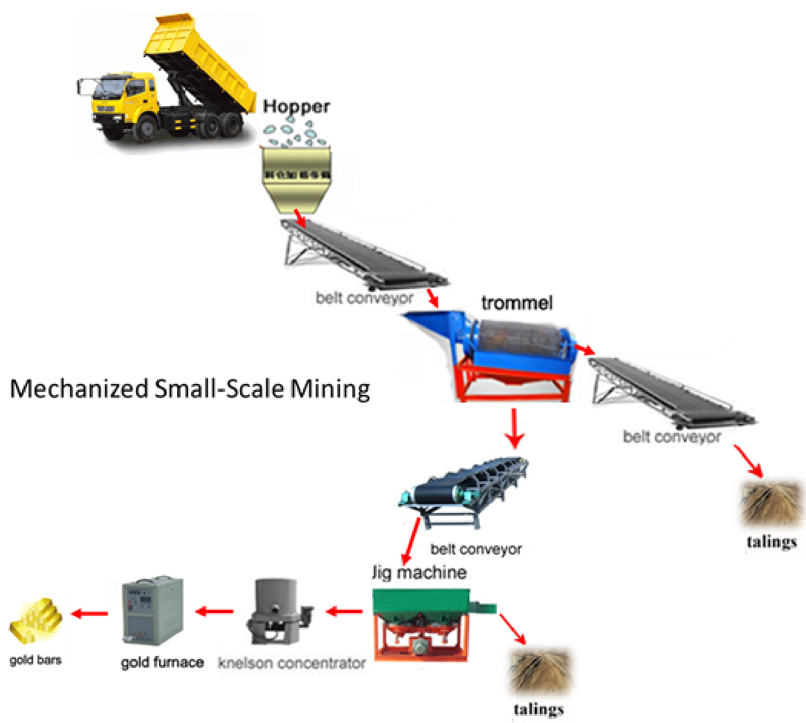

Figure 4. Small-Scale mechanized mining method workflow.

Figure 5. Small-Scale Artisanal Mining. Obtained from: http://camiperd.org/el-instituto-geologico-de-alemania-apoyara-mineria-artesanal-de-rd/

Figure 6. Environment deterioration. Nearby the Study Area. Obtained from: https://elconcreto.com/wp-content/uploads/2018/01/ElConcreto-arcominero.jpg

pacity to do so. (Figures 7 & 8). The authors have the experience of having seen in the Guianese jungle, small areas (from 2 to 5 ha), intervened by artisanal and small-scale miners, which were abandoned and revegetated naturally without the intervention of humans in lapses of about 10 years.

Regarding the soil, the study area has been affected by the intensive use of land by mining, which through inappropriate methods used, flows and degrades the topsoil and the horizons of the soil profile. The physical and chemical characteristics of the analyzed samples define the virgin soil as frank clayey-sandy, and sandy those that have been intervened in years ago. These soils normally show the mixture of the horizons or strata of the soil profile and in some cases even the inversion in terms of the disposition. Figure 9.

The mixing of the soils and the alteration of their internal structure may, in a certain way, be responsible for the variation of the infiltration pattern; since in the intervened soils, the infiltration rate is much slower than in virgin soils. Figure 10.

destruction of the natural forest generates issues not only from the point of view of aesthetics and the modification of the landscape but also from the lack of protection to the soil and affectation of wild fauna which finds its natural habitat and refuge in the forest It has been observed, however, in intervened areas spontaneous development of vegetation appearing species that constitute a secondary vegetation succession. Although this can be interpreted as a deterioration of the original vegetation, it represents a favorable point for the restoration and recovery of the vegetation in the affected areas, even more so when the area presents natural conditions and the ca-

Figure 7. Induced vegetation recovery example. Obtained from: http://cincia.wfu.edu/prensa/publican-articulo-cientifico-sobre-la-recuperacion-de-la-amazonia-afectada-por-mineria/

Figure 8. Natural vegetation recovery evidence. Obtained from: http://cincia.wfu.edu/prensa/publican-articulo-cientifico-sobre-la-recuperacion-de-la-amazonia-afectada-por-mineria/

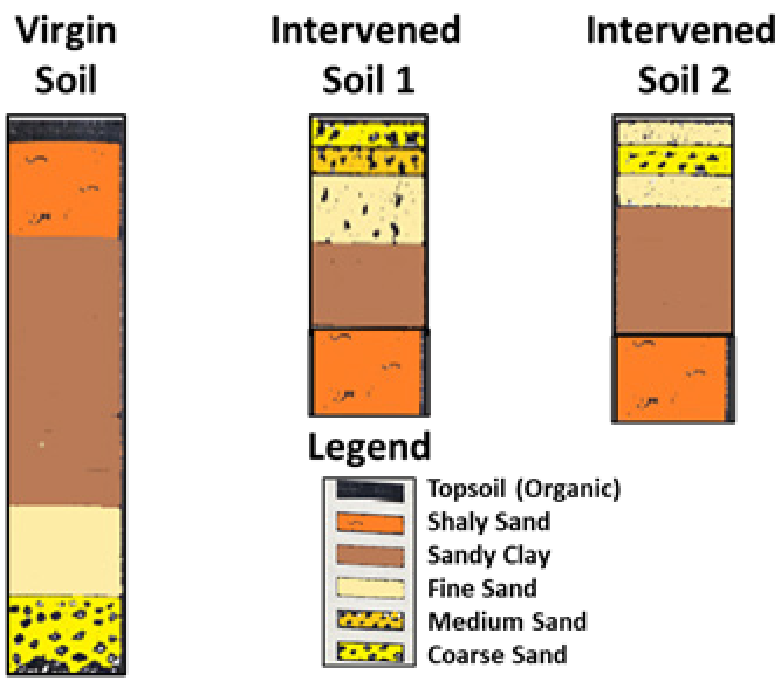

Figure 9. Comparison of profiles of both virgin and intervened soils where the granulometric "inversion" is observed in the attempt to recover the soils as a consequence of the colluvial and alluvial gold mining activity. Study Area. It is obvious how the clay layers in the intervened areas are shallower, which would generate a much sooner saturation of infiltration waters than it would naturally, producing eventual floods with its consequences. (Quaglia & Barbetta, 1991).

Soils are left without any protection whatsoever, being exposed to generalized erosive processes and where the biological activity has very little or no opportunity. The organic matter goes from moderately high in virgin soils to very low in intervened soils, which is a demonstrative factor of soil degradation and its evolutionary condition. Reinforcing the assumption of the lack of nutrient fixation and the low cation exchange capacity surface drainage is also affected since there is the serious problem of the diversion and alteration of the waterways. This problem causes direct effects on the vegetation, flooding forest areas through which the river or stream is forced to pass. Once its bed has been diverted to proceed to the use of the gold ore, both in the floodplain of the river and in its channel. The new channel floods areas that will later draw attention when observing completely dry forest sectors due to the effect of "overwatering". This prevents normal aeration and oxygenation of the roots of the trees, which die due to water excess. Aquatic fauna was also affected by forcibly changing their natural habitat.

Water is the basis of life and undoubtedly the most important resource. The biological activity of the soil, vegetation, and wild, aquatic, and terrestrial fauna will depend on the quality of the available water. To do this, a sampling pattern was designed following criteria of water quality study; locating stations at upstream control points where there was no mining intervention, close to the mining activity, and close to the mixing zone. The obtained results of the analysis showed important values in terms of solid in all its forms. In addition to the general results of the rest of the parameters determined, the values of suspended solids detected in the samples from the final stations increased considerably concerning the control stations, which determined the negative effect of the mining activity on the contamination of the studied rivers and streams. As a consequence, values of significant turbidity were also obtained. It should be noted that the total solids were mostly made up of suspended solids, increasing this situation downstream which could be interpreted as the loss of its dissolution capacity, due to saturation problems. However, the contribution of sediments due to the mining activity has been large and continuous. The hydraulic conduction capacity of the rivers depends on the geometric characteristics of the section and the slope of the channel. Then, results were obtained as a function of the number of suspended solids and the

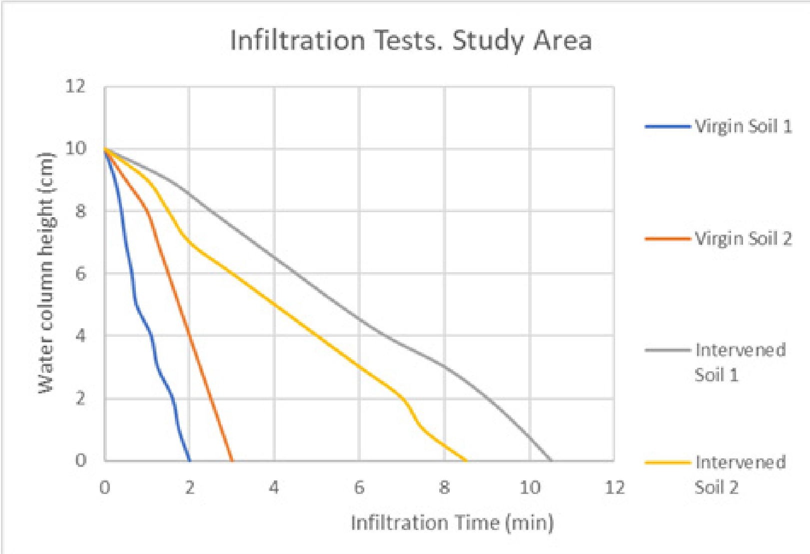

Figure 10. Infiltration tests on virgin and intervened soils. Study area. (Quaglia & Barbetta, 1991).

average flow rates. Water sample analysis regarding pH and dissolved oxygen, were within the tolerable limits, from pH 6 to 8.5, and dissolved oxygen not less than four milligrams per liter, as established in the partial regulation of the Organic Law of Environment at that time. In the study area, it was detected water table associated with gravel and sands from the studied virgin soil profiles. These phreatic layers were found at a depth of approximately 3.6 m, and they were interrupted by mining activity at the time of removal of the material. It was also associated with gold ore. Another problem encountered as part of the environmental deterioration was the terrible conditions in which not only the miners live, but also their families and other people who were located in the area for one reason or another. They stay in tents and barracks, almost always near the work area. Where there are generally stagnant waters and therefore the risk of contracting diseases such as malaria, transmitted by insects found in a favorable environment for its reproduction. There is, of course, the danger of mercury poisoning, since the use made of this element is not controlled; despite having restrictions and prohibitions regarding its use. The miner runs the greatest risk in the recovery stage of the mineral, due to the inhalation of harmful mercury vapors. Culture has been decisive in the search for the causes of this issue, so in addition to a socio-economic and health conflict, it also represents an education problem that is essential to solve.

What is currently happening in the extraction of gold in the km 88 sector

At present, ASM in gold and diamonds is taking place in the materialization of what former President Hugo Chávez presented to the country as the Orinoco Arc in 2012 and then, in the Council of Ministers, approved the Strategic Plan for the Joint Development of the Oil Belt and the Orinoco Mining Arc, all this according to the Ministry of the Popular Power of Ecological Mining Development (n. d.), all that remained there, until his successor's government, through decree 2,248, has denominated as the National Strategic Development Zone "Arco Minero del Orinoco" (AMO, acronym in Spanish) in Venezuelan Guiana, which, as is known, belongs to the Venezuelan Orinoquia, so mining in such territories should be carried out with order, science and technique, which in practice is very far from the "ought to be", on the other hand, all kinds of social calamities have been unleashed, all in according to various authors, among which are cited:

De Souza (2019) revealed that in recent years there has been an exponential growth of violence, of insurgent groups, of miners from neighboring countries, of indigenous people with high levels of mercury in their blood; she also claimed that the region's water was highly contaminated with mercury and other heavy minerals. De Souza argued that Las Claritas and Km 88 are controlled by insurgent groups that try to control more than 63,000 illegal mines that have more than 3,000 illegal miners from Colombia and Brazil.

[YouTube® video] "Mina de oro el dorado Venezuela 2020 2021". Retrieved from: https://www.youtube.com/watch?v=HuT96cpXbxY

[YouTube® video] “La minería de oro en Venezuela, un submundo de caos y violencia”. Retrieved from: https://www.youtube.com/watch?v=6vtagdvghQ0

[YouTube® video] “El peso del oro: violencia en el sur de Venezuela”. Retrieved from: https://www.youtube.com/watch?v=-n4BVmKEGqw

[YouTube® video] “Illegal Gold Mining in Venezuela”. Retrieved from: https://www.youtube.com/watch?v=Jrs9fq6fFZw

Mora & Rodríguez (2019) as cited in Aguilar & El Fakih (2021) pointed out as problems generated by the Orinoco Mining Arc the forced displacement of indigenous people, deterioration in the health of these citizens, social neglect by the State, increase in military-police interventionism, and exacerbation of violence in communities.

Lozada et al. (2020) argued that the mining business is not one of the traditional activities of indigenous peoples, despite the fact that some of their leaders now justify it and carry it out as a result of the fact that these peoples were already in the process of transculturation, which it facilitated the exercise of an activity that was not normal for them since their ancestors carried out artisanal mining since pre-Columbian times. Based on exposed by Milano (2008), Grillet et al., (2009), Lozada (2017), and Vitti (2018), they listed the following impacts caused by indigenous commercial mining in the 43 sites they studied, namely: “: the destruction of ecosystems and rivers topography, habitat fragmentation, death and displacement of fauna, pollution of water and fish by sediment and mercury, mercury-borne diseases, favorable habitats for malaria-carrying mosquitoes, increased incidence of malaria, the emergence of criminal armed groups, increased incidence of prostitution and violent deaths, as well as misuse of drug and liquor”

Machado-Allison & Chernoff (2020) stated that with the mining arc it has not been possible to change the unproductivity and inefficiency in mining, additionally, they revealed the existence of illegal acts and abuses of power, of corruption, also, they pointed out that it was not applying the constitutional principle of control and approval of contracts by the Legislative Power and that in all this the most affected are the environment and the indigenous and creole peoples who traditionally live in the areas.

Moya et al. (2021) stated:

“... there is the case of men who moved to the south of Bolívar state with a job offer that included a salary, lodging, and food, and ended up working in a mine for more than 12 hours a day, without any kind of protection, having as an obligation the delivery of up to half of their profits to the so-called “unions” (Venezuelan armed groups) and to the Colombian armed groups that control the sector and being victims of constant threats in the event of any error, or breach of the rules by these imposed, with actions such as the amputation of some of their limbs and even death. In the case of women, their involvement with prostitution is more frequent in mining areas, and if they have any disease, they are, or expelled from the population, or punished with physical abuse. These activities not only occur as a result of misleading offers but also the situation of people who, attracted by the vision of mining as a mechanism to obtain quick money, undertake their journey to these areas, given the scarcity of opportunities that exist in the country and end up trapped in the dynamics of the mining sector.

Minors are also victims of mining, both directly and indirectly. In 2019, Cecodap reported that 45% of mine workers were children and adolescents. Directly, since their kinship with miners leads them to inhabit the mines, and their size makes it easier for them to enter the narrow-improvised tunnels for the extraction of gold. And indirectly, because their parents go to the mines and leave them unprotected, with relatives or acquaintances, and end up wandering in the streets as in the case of the children in the Plaza de El Callao, where a group lives whose ages vary between 8 and 12 years old."

We could also cite abundant information on social networks, generated by politicians and environmentalists, which have a lot of visual impacts (works of art from photography and documentaries), but the vast majority lack field studies with samplings, results, and analysis. So far the visual display of what would be happening is similar to what happened before the "State atrocity" which is colloquially known as "Mining Arc", it is also similar to other devastation carried out by artisanal and small-scale miners in other countries. Basically, what is observed is not mining but a rather irrational plundering of resources of nature and of humanity itself, with which no one, with a minimum environmental awareness, could agree, but the real solution does not go through the extinction of this production subsector but through its complete transformation and support to realize its evolution, on the other hand, its extinction has never been achieved in the countries where it has been tried, since the problem is much more complex than what can be seen by those who only approach from one, two or three aspects of the problem, or from a non-scientific approach and, yes, very fanatic. Fanaticism will never offer sustainable solutions over time.

Proposal

From the technical point of view, the recommendations made by Quaglia & Barbetta (1991), as well as what is indicated in Sernageomin (ND), Sernageomin (2003a), Sernageomin (2003b), UPME (2007), Lujan (2008), UNEP (2008), Telmer & Stapper (2012), Eppers (2014a), Eppers (2014b), Meller & Meller (2021) and all others that have been mentioned so far are perfectly applicable and very positive for the reduction of negative impacts of the ASM, however, it is necessary to understand that these scales of mining should be helped to disappear through evolution, becoming clear that the proposal that arises below, is not aimed at achieving the totality of the extinction of ASM, since it is really impossible given that not every miner feels the need to evolve in what he does and that is perfectly natural in humanity.

It is necessary to keep in mind at all times that what prevents the evolution of miners, who wish to evolve, is the absence of knowledge about reserves that may exist, in such a way that it is necessary to promote from the State, that small-scale miners could perform geological exploration, but, normally, handmade and small-scale miners are found in survival situations, either be-

[YouTube® video] "Disminución de Mercurio en la Minería". Retrieved from: https://www.youtube.com/watch?v=oVWCF2-eVu4

[YouTube® video] "Disminución de Mercurio en la Minería". Retrieved from: https://www.youtube.com/watch?v=BmJTSptLab4

cause they enter the sub-sector due to prolonged unemployment or because culturally, despite receiving fortunes occasionally, they do not have the minimum knowledge of administration to preserve the riches that obtain and in many cases do not even feel the need to prepare for the most everyday situations in the exercise of these mining scales such as non-obtaining mineral or obtaining as little that production costs cannot be defrayed.

Based on the above, it is having that even though some miners realize that it is preferable to reduce the volatility produced by dispersed deposits and the absence of reserves, they do not have the money and other necessary resources. Some people have always proposed that the State create financing programs for small-scale miners to carry out exploration and others have proposed that the State carry out exploration for this scale of mining; in this proposal, it is not contemplated that the State carry out extremely high-risk expenses such as these since it is irrational to do so.

In small-scale mining in Venezuelan Guiana, there have been mining cooperatives and civil mining associations, with concessions or mining contracts granted by the State, that is, with real rights in the first case and precarious rights in the second case, which is important to be able to evolve, if it is the first case; additionally, in some of them there were people with vision and spirit to evolve, miners who realized that they could do better if they took steps to reduce the enormous volatility that characterizes this subsector, but in all the attempts they made to try to evolve, they encountered obstacles in the Venezuelan legal framework, in the mentality of officials and inside public opinion. Basically, perhaps unintentionally, everything is designed so that they are always small, vulnerable, dependent on the state while also being a heavy burden on the state and society, prey to leaders with secondary intentions prioritizing themselves and not for the miners they represent, and much less the communities.

However, as part of the nature of some human beings, there are always those who do not conform to the situation in which they find themselves and want to produce changes, in such a way that at the end of the 90s, in some organizations of small miners, part of the income was used to carry out some exploration, but they could not sustain the initiative, in such a way that the small miners began to think that the State should give them money to explore as well as carry out a technological reconversion, that would allow them to replace hydraulic monitors and the use of mercury, of course, this option is unfeasible if those who govern are responsible and knowledgeable about the mining business, so the best option is to modify the legal framework of both mining and cooperatives, since it is necessary to allow that miners can partner with each other and/or with national or foreign businessmen, to undertake formal geological explorations based on the legal framework that is in force, in such a way that by achieving quantification of reserves, they can abandon the status of small-scale miners to higher scales. Logically, it is contemplated in the legislation that small-scale miners obtain precarious rights, as it should be since they do not have proven reserves, but that obtain real rights such as exploration concessions could be easy for them, if through association with companies, nationals, or foreigners, and/or with their resources, can justify obtaining a concession of this type.

The proposals made here for gold and diamonds ASM in Venezuelan Guiana have been conceived without considering the diverse crime problems existing today and which have been briefly described in previous paragraphs, drug trafficking, human trafficking, slavery, the mafias with their diverse and changing names, the presence of illegal Creole “military” forces and foreign guerrillas, are problems for which the authors of this proposal do not have any expertise because the experience is in geosciences and not in the field of detective investigation or intelligence services. It is necessary, to implement what is recommended here, that order be previously restored in Venezuelan Guiana.

Considering that there is a lot of misinformation regarding possible deposits suitable for artisanal and small-scale mining, but taking into account that there is a socio-economic pressure for those who carry out these activities to try to obtain income for their survival and that of their families, in a ruined country in which the salary does not sufficiently reward the work done to obtain it, it is necessary to carry out a transitional period that has been conceived as follows:

Artisanal and small-scale miners should be allowed to work only in areas already intervened, not in virgin areas, nor inside watercourses, nor between the banks of rivers and the line parallel to them 300 meters away, all this based on article 54 of the current water law. The exception about bodies of water could be considered only to avoid aggradation, dissolve aggradation or prevent damage to navigation, or any other reason accepted by the national institution with competence in the environment.

The organization and association of miners should be promoted using any of the forms of association (civil or commercial) in force in Venezuelan legislation.

Each artisanal miner could be assigned plots of 2,500 m2, while each formal organization of artisanal miners, as an incentive to promote the organization of these miners, could be assigned 5,000 m2 for each associate member. Individual small-scale miners could be allocated a plot of up to 1 ha, while small-scale miners' organizations could be awarded plots of up to 2 ha for each member of the requesting organization.

In each ASM´s area, the existence of natural or legal persons, authorized by the institution with competence in mining, who provide services of heavy machinery, equipment, concentration plants, and mineral trading should be promoted.

Underground work should not be carried out without the approval of mining engineers whose professional practice has been approved by the institution with competence in mining. The loss of human life due to poorly executed mining is not acceptable in any way.

It should be promoted that the operations of both artisanal and small-scale miners are coordinated in each area so that all of them contribute to the materialization of the environmental recovery of the area.

The use of hydraulic monitors can be allowed in areas environmentally impacted by previous exploitations and in tailing deposits, as long as the operations with this equipment do not generate more damage to the existing watercourses or the surrounding virgin environment.

All the waters and pulps from the exploitation and the concentration must be directed to sedimentation and clarification lagoons, of which there would be as many as required so as not to return to the rivers, lakes or streams, waters of lower quality than that which was obtained from these bodies of water, preferably, mining operations should be supplied mainly from the waters present in the lagoons. To have enough lagoons, mining excavations that have already been "totally" exploited can be used.

It is recommended that national or foreign universities that train professionals in mining engineering, environmental engineering or chemicals, both undergraduate and postgraduate, as well as research centers or equivalent, private or public, national or foreign, carry out perennially research and provide support, in each zone of artisanal and small-scale miners, about the best products to use to make the sedimentation process, clarification and improvement of the quality of the waters coming from the operations and concentration plants more efficient, in such a way that only the waters of equal or better condition to the one they originally had, are those that are returned to nature and so that each aspect related to artisanal and small-scale mining is better and better in favor of obtaining real improvement and continuous quality of life for miners.

Neither artisanal nor small-scale miners would be allowed to use chemical substances to capture gold, they will only be able to make hydro-gravimetric concentrations and take their concentrates to authorized places to subject them to adequate processes for the recovery of the mineral. Miners or artisanal or small-scale mining organizations that have adequate facilities in accordance with the national institution with competence in the environment and that have mining engineers or chemical professionals as responsible for them are excepted. It is necessary to modify decree 2.412 of 2016.

It will be necessary to design a practical plan to re-educate artisanal and small-scale miners about the use of mercury and the wrong way they have normally been operating; they must be shown the falsehood of the various myths they have regarding mercury and the mistakes they always make in their production operations; miners should be convinced of superior recovery with the alternative methods that they must be proposed to have less impactful mining compared to what they normally use. It is necessary to reiterate the practical nature that the implementation of this recommendation should have, as well as the need to convince rather than impose.

During the years that the transition period would last, new areas would be identified in which formal jobs of artisanal and small-scale miners could be organized, which could be areas that, after explorations carried out by industrial mining, do not interest them and they have returned to the nation or explored areas that the companies have left out of the project and that could be exploited by artisanal and small-scale miners without affecting the operations of the company and prior release of responsibilities to the company for the environmental impacts that could be generated by ASM. In any case, virgin areas where the existence of minerals of interest to ASM is unknown should not be allowed to be intervened. On the other hand, in areas that industrial-scale mining companies could allow to be exploited by ASM, only precarious rights may be granted as they would be areas in active concessions. Based on what is stated here, the following is recommended:

The exploitation of the parcels that are granted for ASM must be exploited within the framework of a strategy that allows the environmental recovery of the entire surface that has been planned to be affected, in such a way that each of the natural or legal persons to those who are awarded the plots, they will contribute to such objectives both, financially, and by following the technical guidelines that have been approved by the institution with competence in mining.

The first recommended stage consists of carrying out a topographic survey of the area to be intervened, it should also be spatially inventoried, it may be with the help of a geographic information system, the various species that are found in the area where the mining will be carried out is It is advisable to collect seeds and seedlings of the native vegetation as well as a characterization of the soils, however, in this matter, the appropriate procedure must be that established by professional specialists in environmental recovery as long as it has the endorsement of the national institution with competence in the environment.

The next stage would contemplate deforestation if there are forests; it is recommended that it be legally allowed to make use of the existing useful wood for the necessary infrastructures in the mine, if it were in the interest of the miners, if there were species of interest to the markets and they are not going to be used in the project, they should be commercialized, and the money from the sale, reserved to be used in the environmental recovery plan, the rest of the forest material, which could not be commercialized or used in the project, must be properly preserved at the judgment of environmental professionals to be used in the work of environmental recovery.

All the topsoil and each underlying horizon must be removed with heavy machinery, mining rakes, or manually and stacked separately, in places and conditions previously established to preserve them without deterioration until it is necessary to use them for environmental recovery. The use of hydraulic monitors could be allowed in the mineralized layer as long as it is not soil. When it comes soils restoration time and whenever possible, the topsoil and overburden or sterile material, which are found above the mineralized layer, must be deposited back in the same sequence in which it was removed, especially when it is not homogeneous, this will guarantee that the best material for integral recovery it is closer to the surface since the pursued objective is recovering strata configuration as close as possible to the natural profile of the soil.

Besides the call for a review of current legislation, this proposal suggests, among other things, taking into account the following specific aspects: 1.- Training and education for mining workers and mining communities regarding the application of efficient processes on rational profit of natural resources, social-economic aspect, effective administration, financial management, as well as integral health. 2. Soil restoration & preservation from degradation and erosional process. 3.- Reforestation. 4.- Restoration of biological processes. 5.- Preservation and recovery of aquatic and terrestrial habitats. 6.- Landscape restoration.

It is important to highlight that, for this scale of mining, in the options exposed in the second stage of this proposal, in which areas would be opened for ASM in which reserve estimates have been previously made, exploitation plans and closure of mines plans framed in the environmental impact study must be made, which must rigorously contemplate the costs required for all plans to be carried out as planned, of course, such costs must be considered in the economic feasibility study to determine the feasibility of undertaking the project, the decision could be made based on a cost-benefit analysis.

What has been stated in paragraphs 2 to 5 and 8 to 10 relative to the transitional period should be sustained in this other modality of ASM operations.

Taxes should not be levied on the mining production of artisanal and small-scale miners, but they must pay the costs of public administrative management of their operations, and must also be deducted them when selling their productions, a percentage that must be directed to a social investment fund to benefit the community(ies) close to the extraction sites, such funds would only use the money for projects approved by a simple majority in each community and could only be projects aimed at the comprehensive improvement of the quality of life of the communities and the socioeconomic sustainability of the region.

Such funds should have an Administrative Council made up of a member of the community (elected by two-thirds of the adults of the community and revocable at any time with 2/3 of the votes of the adults of the community), a representative of the mayor's office appointed by the Municipal Council and another member designated by the institution with competence in mining whose appointment has been published in the Official Gazette of the Republic.

The administration of the projects would be carried out by members of the communities, if they are proven trained to administer, otherwise, they could contract the administration to natural or legal persons, in any way, those who administer projects will be accountable to the Administrative Council.

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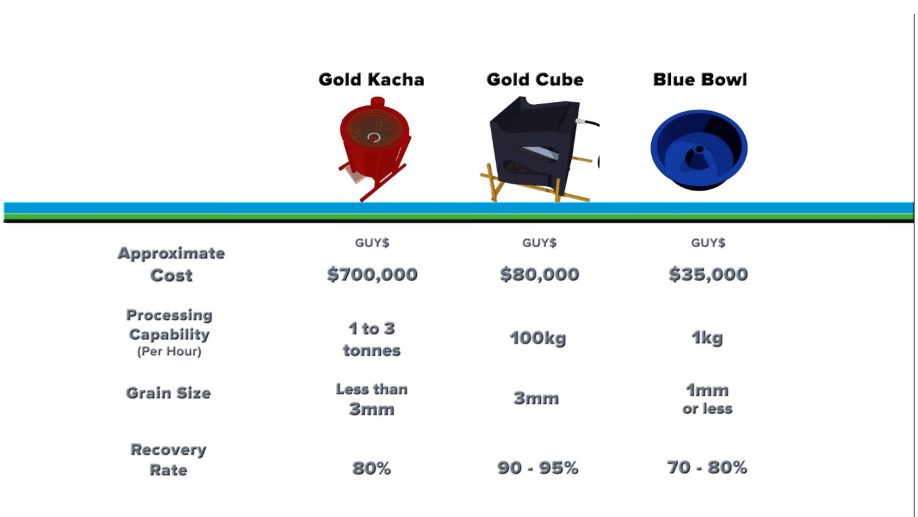

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Liquid metal proven to be cheap and efficient CO2 converter*

13 OCT 2021 NEIL MARTIN

A global collaboration, led by researchers from UNSW, has shown how liquid gallium can be used to help achieve the important goal of net zero carbon emissions.

Nanoparticles of liquid gallium have been shown to help break down carbon dioxide by way of triboelectrochemical reactions. Image: Shutterstock.

Engineers from UNSW have helped to discover a cheap new way to capture and convert CO2 greenhouse emissions using liquid metal.

The process can be done at room temperature and uses liquid gallium to convert the carbon dioxide into oxygen and a high-value solid carbon product that can later be used in batteries, or in construction, or aircraft manufacturing.

A team from the School of Chemical Engineering, led by Professor Kourosh Kalantar-Zadeh, worked in collaboration with researchers at University of California, Los Angeles (UCLA), North Carolina State University, RMIT, University of Melbourne, Queensland University of Technology, and the Australian Synchrotron (ANSTO).

Their findings have been published in the Advanced Materials journal and Professor Kalantar-Zadeh and his team say the new technology has the potential to be used in a wide variety of ways to significantly reduce the levels of greenhouse gases in the atmosphere.

"We see very strong industrial applications with regards to decarbonisation. This technology offers an unprecedent process for capturing and converting CO2 at an exceptionally competitive cost," said Junma Tang, the first author of the paper.

"The applications could be in cars to convert polluting exhaust gases, or even at a much larger scale at industrial sites where CO2 emissions could be immediately captured and processed using this technology.

"We have already scaled this system up to two-and-a-half litres dimensions, which can deal with around 0.1 litre of CO2 per minute. And we've tested that running continuously for a whole month and the efficiency of the system did not degrade."

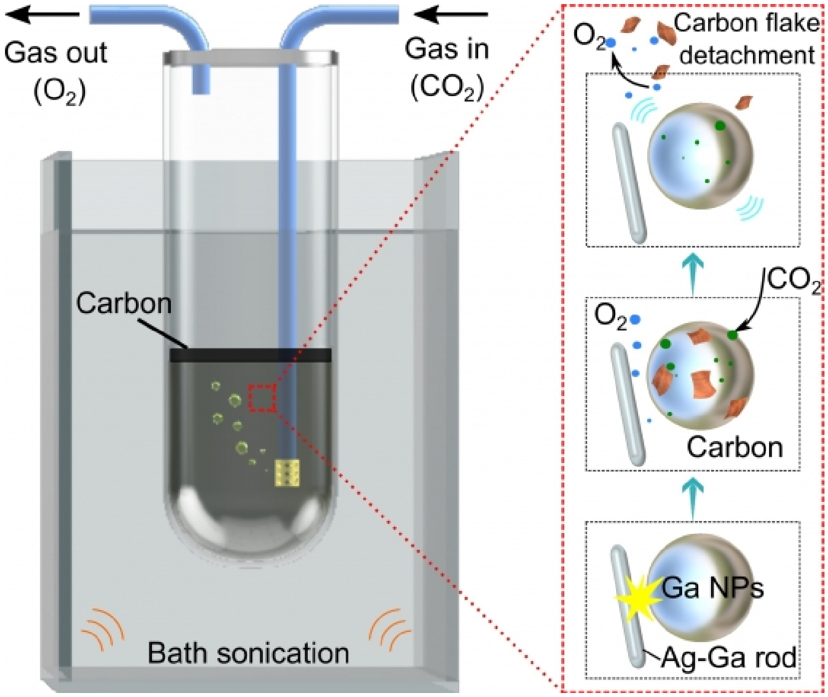
The newly discovered process dissolves captured CO2 gas into a solvent around nanoparticles of gallium, which exist in liquid state above 30°C.

The reactor also contains nano-sized solid silver rods that are the key to generating the triboelectrochemical reactions that take place once mechanical energy (e.g. stirring/mixing) is introduced.

A triboelectrochemical reaction occurs in solid–liquid interfaces due to friction between the two surfaces, with an electric field also created that sparks a chemical reaction.

The reactions break the carbon dioxide into oxygen gas, as well as carbonaceous sheets which 'float' to the surface of the container due to differences in density and can therefore be easily extracted.

* https://newsroom.unsw.edu.au/news/science-tech/liquid-metal-proven-be-cheap-and-efficient-co2-converter



UNSW researchers have helped show how carbon dioxide can be broken down cheaply and efficiently via a process that dissolves captured CO2 gas into a solvent around nanoparticles of gallium.

In their paper, the research team show a 92 per cent efficiency in converting a tonne of CO2 as described, using a low energy input. They estimate it equates to a cost of around $100 per tonne of CO2 (when the input gas pressure is held at several times above the atmospheric pressure).

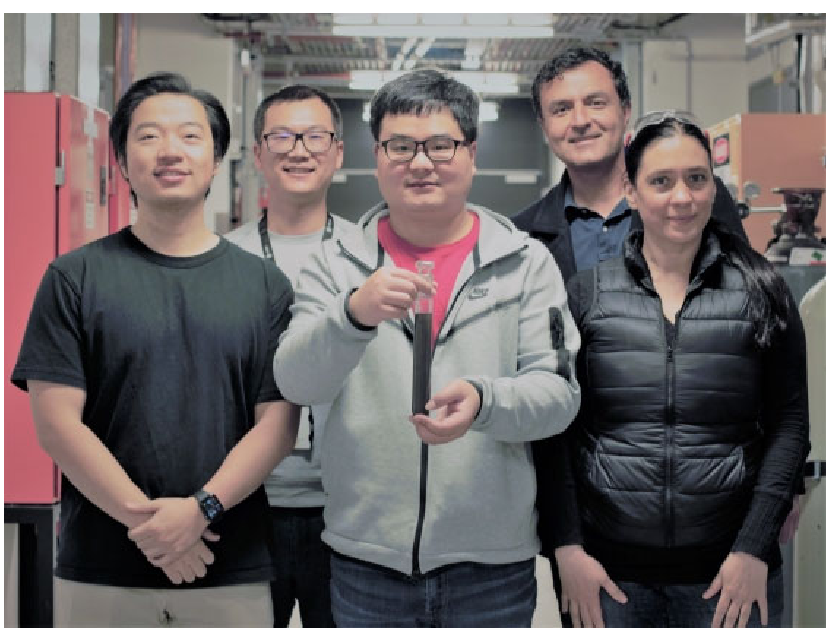
In order to commercialise the research, a spin-out company called LM Plus has been established with the support of UNSW's Knowledge Exchange – a program that helps transform research discoveries into successful innovations to benefit society, along with seed investment from Uniseed.

UNSW has become a shareholder as part of a license agreement with the company.

"This is a very green process which also produces a high-value carbonaceous sheet which can then be sold and used to make electrodes in batteries, or for carbon fibre materials that are used in high-performance products like aircraft, racing cars, and luxury vehicles," said Paul Butler, Uniseed's Investment Manager and director of LM Plus.

"What we are working towards now is to raise funds to build a larger size proof-of-concept for this system to work within a 40-foot container –the size of a truck trailer – that could ultimately help industrial sites immediately capture any CO2 emissions and convert them."

LM Plus hopes to be able to build that much larger system within 15 months and is already in talks with potential commercial partners about other ways of implementing the new technology.



A selection of the UNSW research team who helped prove liquid gallium can be used to break down carbon dioxide gas. Back row: Jianbo Tang, Professor Kourosh Kalantar-Zadeh. Front row: Zhenbang Cao, Junma Tang, Claudia A. Echeverria.

Petrofísica
Petrophysics
Petrofísica

Flow units characterization based on reservoir rock quality and saturation of producible fluids to support decision-making in preliminary petrophysical evaluations and early well completion programs

Caracterización de unidades de flujo basada en la calidad de la roca yacimiento y la saturación de fluidos producibles para apoyar la toma de decisiones en evaluaciones petrofísicas preliminares y programas de terminación de pozos

Caracterização das unidades de fluxo com base na qualidade da rocha do reservatório e saturação de fluidos produzíveis para apoiar a tomada de decisão em avaliações petrofísicas preliminares e programas de conclusão inicial de poços

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Recibido: 28-9-21; Aprobado: 29-10-21

Abstract

When characterizing the reservoirs through "Flow Units approach" there will always be the need of ranking them to either qualify them after the application of a Petrophysical Model or assisting Reservoir Engineers on Initial Completion programs. In this regard, this work consists of a workflow development to determine and classify flow units, based on rock quality index and saturation of producible fluids in hydrocarbon reservoirs. For this ranking, properties such as the pore throat radius, capillary pressure and relative permeabilities were considered, in order to determine the saturation of producible fluids, as well as Flow Capacity under certain conditions of water saturation for a given reservoir. Required Reservoir Properties as average porosity, permeability and Pore throat size (Rock Types) were obtained from a selected data set of available Wells for this study. Well Log curves and specific Core data were processed through existing utilitarian software called EPP_1.0 (by its acronym in Spanish) & PFS_1.0 (PetroFlow System) (Figures 1 & 2) supplied by the Sponsoring Consultancy Company "Inter-Rock". EPP is a system designed to make preliminary petrophysical evaluations on a "portable Device" which can be implemented "anywhere- anytime". Results from this stage are used as "Input Data" for second stage using Petro Flow System to generate and rank Flow Units according to Rock Quality, mainly based on Dominant Pore Geometry. After that, special core analysis data, either from studied reservoirs or analogs, are included to the ultimate Integrated workflow to estimate Producible Fluid Saturations and Flow Capacity in the Reservoirs of interest which consisted of consolidated sandstones. Finally, a third stage through an internally developed algorithm, called SFP_1.0 (Figure 3), was developed to explore future enhancements on reservoir flow unit's determination, decision making process optimization on early Well completion Plans and future integrated automatization opportunities on this regard. The integration of these three algorithms, allowed to generate a new and definite workflow called S.H.P (by its acronym in Spanish) which was able to rank flow units in a quick and efficient way, just a few minutes after getting the well logs and the required data from the field. Once the petrophysical properties were calculated, the flow units ranked and the producible fluid saturations determined, these results were compared with the production data of studied available wells, so it was possible to establish high certainty relationships between the calculated reservoir properties and the field operational data.

Resumen

Al caracterizar los yacimientos a través del "enfoque de unidades de flujo", siempre será necesario clasificarlos tanto para calificarlos después de la aplicación de un modelo petrofísico o para apoyar a los ingenieros de yacimientos en los programas iniciales de completación de pozos. En este sentido, esta experiencia consiste en el desarrollo de un flujo de trabajo para determinar y clasificar las unidades de flujo, con base en el índice de calidad de la roca y la saturación de fluidos producibles en yacimientos de hidrocarburos. Para este ranking se consideraron propiedades como el radio de garganta de poros, la presión capilar y las permeabilidades relativas, con el fin de determinar la saturación de fluidos producibles, así como la Capacidad de Flujo bajo ciertas condiciones de saturación de agua para un reservorio dado. Las propiedades requeridas del yacimiento como la porosidad promedio, la permeabilidad y

Palabras clave/Keywords/Palabras-chave:
Aceite residual, agua irreducible, água irredutível, capillary pressure, flow units, *fluidos producibles, fluidos produzíveis, flujo fraccional, fluxo fracionário,* fractional flow, irreducible water, *óleo residual, permeabilidad relativa, permeabilidade relativa, presión capilar, pressão capilar,* producible fluids, relative permeability, residual oil, rock types, *tipos de rocas, tipos de rochas, unidades de flujo, unidades de fluxo.*

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el tamaño de la garganta de los poros (tipos de roca) se obtuvieron de un conjunto de datos seleccionados de pozos disponibles para este estudio. Las curvas de registros de pozos y los datos de núcleos específicos se procesaron a través del software utilitario existente llamado EPP_1.0 (por sus siglas en español) y PFS_1.0 (PetroFlow System) (Figuras 1 y 2) suministrados por la Empresa de Consultoría Patrocinadora "Inter-Rock". EPP es un sistema diseñado para realizar evaluaciones petrofísicas preliminares en un "dispositivo portátil" que se puede implementar "en cualquier lugar y en cualquier momento". Los resultados de esta etapa se utilizan como "Datos de entrada" para la segunda etapa utilizando PetroFlow System para generar y clasificar las unidades de flujo de acuerdo con la calidad de la roca, principalmente con base en la geometría de poros dominante. Después de eso, los datos de análisis de núcleos especiales, ya sea de los reservorios estudiados o análogos, se incluyen en el flujo de trabajo integrado definitivo para las saturaciones de fluidos producibles y la capacidad de flujo en los reservorios de interés que consistían en areniscas consolidadas. Finalmente, se desarrolló una tercera etapa a través de un algoritmo desarrollado internamente, llamado SFP_1.0 (Figura 3), (saturación de Fluidos Producibles) para explorar futuras mejoras en la determinación de unidades de flujo de los yacimientos, la optimización del proceso de toma de decisiones en los primeros planes de completación de pozos y futuras oportunidades de automatización. La integración de estos tres algoritmos permitió generar uno nuevo y definitivo flujo de trabajo denominado S.H.P. (Saturación de Hidrocarburos Producibles) capaz de clasificar las unidades de flujo de manera rápida y eficiente, apenas unos minutos después de obtener los registros de pozo y los datos requeridos del campo. Una vez calculadas las propiedades petrofísicas, jerarquizadas las unidades de flujo y determinadas las saturaciones de fluidos producibles, estos resultados se compararon con los datos de producción estudiados de los pozos disponibles, por lo que fue posible establecer relaciones de alta certeza entre las propiedades del yacimiento calculadas y los datos operativos de campo.

Resumo

Ao caracterizar os reservatórios através da "abordagem de Unidades de Fluxo" sempre haverá a necessidade de classificá-los para qualificá-los após a aplicação de um Modelo Petrofísico ou auxiliar Engenheiros de Reservatórios em programas de Completação Inicial. Nesse sentido, este trabalho consiste no desenvolvimento de um workflow para determinar e classificar as unidades de fluxo, com base no índice de qualidade da rocha e saturação de fluidos produzíveis em reservatórios de hidrocarbonetos. Para esta classificação, propriedades como o raio da garganta dos poros, pressão capilar e permeabilidades relativas foram consideradas, a fim de determinar a saturação de fluidos produzíveis, bem como a Capacidade de Fluxo sob certas condições de saturação de água para um determinado reservatório. As propriedades de reservatório necessárias como porosidade média, permeabilidade e tamanho da garganta de poros (tipos de rocha) foram obtidas a partir de um conjunto de dados selecionados de poços disponíveis para este estudo. As curvas do Well Log e dados específicos do Core foram processados através do software utilitário existente denominado EPP_1.0 (por sua sigla em espanhol) e PFS_1.0 (Sistema PetroFlow) (Figuras 1 e 2) fornecidos pela Consultoria Patrocinadora "Inter-Rock". EPP é um sistema projetado para fazer avaliações petrofísicas preliminares em um "dispositivo portátil" que pode ser implementado "em qualquer lugar, a qualquer hora". Os resultados desta fase são usados como "dados de entrada" para a segunda fase usando o Petro Flow System para gerar e classificar as unidades de fluxo de acordo com a qualidade da rocha, principalmente com base na geometria do poro dominante. Depois disso, dados de análise de núcleo especiais, de reservatórios estudados ou análogos, são incluídos no fluxo de trabalho integrado final para estimar as saturações de fluido produtivas e a capacidade de fluxo nos reservatórios de interesse que consistiam em arenitos consolidados. Finalmente, um terceiro estágio por meio de um algoritmo desenvolvido internamente, chamado SFP_1.0 (Figura 3), foi desenvolvido para explorar melhorias futuras na determinação da unidade de fluxo do reservatório, otimização do processo de tomada de decisão em Planos de conclusão de Poço iniciais e futuras oportunidades de automatização integrada a este respeito . A integração destes três algoritmos, permitiu gerar um novo e definitivo workflow denominado SHP (por sua sigla em espanhol) que foi capaz de classificar as unidades de fluxo de forma rápida e eficiente, poucos minutos após a obtenção dos registros do poço e os dados do campo. Uma vez que as propriedades petrofísicas foram calculadas, as unidades de fluxo classificadas e as saturações de fluido produzíveis determinadas, esses resultados foram comparados com os dados de produção dos poços disponíveis estudados, de modo que foi possível estabelecer relações de alta certeza entre as propriedades do reservatório calculadas e os dados operacionais de campo .

Acknowledgment

We would like to thank the Inter Rock board of directors for allowing to develop and to publish this workflow, making possible to add value to specific procedures to find the more efficient links between static and dynamic reservoir modeling. Additionally, we give thanks to the Petroleum Engineering Department of "Universidad de Oriente" (Puerto La Cruz-Venezuela), especially to Professors Roberto Salas, Oly Guerra, Mario Briones, Tania Gonzalez, Gisela Lopez, and Yuraima Parra, as well as UDO & IUPSM Professor Aquiles Torrealba, for the support, collaboration, affection, and trust they placed during the development of previous workflows, used as references for this integrated work.

Figure 1. Inter-Rock EPP Automated System for Preliminary Petrophysical Evaluations.

Figure 2. Inter-Rock PFS Automated System for Flow Units Ranking as per Rock Quality.

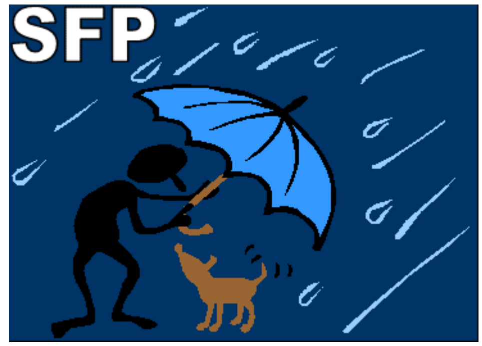


Figure 3. Inter-Rock SFP Automated System for Flow Units Ranking as per Producible Fluids.

Introduction

Rock Type approach, as well as storage and flow capacity determination, are "Key Factors" to assess the quality of reservoir rocks, which, among other things, is determined by the pore volume, the pore throat size distribution and the permeability. (Hartmann & Beaumont, 1999). Eventually, the process to determine reservoir producible fluids could take considerable time, since the expected results, both numerical and graphical, need certain knowledge, procedures, tools and/or software that hardly ever are available "all at once", and when available, could be done separately at best, usually making this a non-so straight forward procedure to achieve a complete and satisfactory assessment. This suggests the need of an express workflow that performs a preliminary evaluation in a more expeditious manner, which also would streamline the process and minimizes uncertainty in the results. All this, in order to speed up turnaround time and expeditiously generating valid technical options to facilitate early wins in decision-making process. The mentioned workflow is based on the ranking and selection of prospective reservoirs in a given well, generating a prioritized list of flow units through an integrated and detailed petrophysical analysis to provide reliable results in a timely manner. For this, the input data consisted of Capillary Pressure, Relative Permeability and that previously generated by EPP and PetroFlow System applications. The main purposes for flow units ranking which, at the same time, are based on rock quality and producible fluid saturations, are optimizing the timing, reducing costs and minimizing error margin. In order to establish an ultimate Flowchart to eventually Implement the resulting workflow, it was required a full understanding of current process of fluid saturation evaluations in oil fields, the optimization of producible fluid saturation assessments through Fluid mobility analysis and a carefully documented logical sequence of applied physical and mathematical theories to obtain optimum results from selected input parameters.

Background

G.W. Gunter et al., SPE, Amoco EPTG in 1997, developed a work that consisted of early determination of reservoir flow units using an integrated petrophysical method. This paper used case histories to introduce a graphical method for easily quantifying reservoir flow units based on geologic framework, petrophysical rock/pore types, storage capacity, Flow capacity and reservoir delivery speed. They concluded the earlier in the life of a reservoir this process is used, the greater the understanding of future reservoir performance. One of the most important results in this process was the possibility to employ the least number of flow units and still keep honoring the character of the "foot by foot" data for simulation studies.

Álvarez, H., in 2003, developed a work that consisted of models for the interpretation of pressure tests as a tool for estimating the characteristic parameters of reservoir drainage areas. These models relate hydrocarbon production to downhole pressure changes, considering the geometric shape of the drainage area, formation characteristics, as well as boundary conditions.

Quaglia, A.; Panesso, R.; Subero, R.; Malave, L.; González, Z.; JOLEIP. 2004. This work consisted in the implementation of an integrated workflow through a portable system in order to support the decision-making process based on preliminary petrophysical properties and subsequently on petrofacies determination which indicated Reservoir Quality, Hydrocarbon storage capacity & Flow capacity in order to estimate the amount of existing hydrocarbon and the percentage of most probable Fluids Flow. This system was developed using "The CASE methodology", using Borland Delphi 7 as a coding and compilation tool for EPP App, with the InterBase 7 database manager. While MERISSE methodology was used in the development of the Petro Flow System; Visual Basic 6.0 software as a coding and compilation tool for PFS.[5]

Claib, A. and Presilla, R., SPE Student Chapter Seminar 2010. Amin Claib & Ricardo Presilla developed a software to determine and classify Flow Units base on Rock Quality and Producible Fluids Saturation in Hydrocarbon Reservoirs as part of internal resources for Inter-Rock Company. Automated science has gained adherents, and consequently, they have given the implanted systems reliability, therefore, their applicability in important areas and their influence on decision-making. Automated Support Systems combine sophisticated analytical models and data to support the different stages of the decision-making and evaluation processes.

Previous Workflows.

The Producible Hydrocarbon Saturation Workflow (S.H.P.) by its acronym in Spanish, has been developed following the Object-Oriented Methodology, based on previous Software life cycles and a final Unified Flowchart Model, allowing the application of one integrated system with some ideas from the following previous stages:

1. Preliminary Petrophysical Evaluations. This first stage starts with preliminary petrophysical evaluations applying EPP_1.0. workflow (Figure 4), in order to determine "geological units" and their petrophysical properties: volume of clay, effective porosity, water saturation and permeability. It can be implemented "anywhere- anytime". Preliminary QC Well log curves are processed using EPP_1.0 application immediately after a new well has been logged, although for the purposes of this phase, petrophysical properties can be also obtained from any commercially available software that meets the requirements.

2. Flow Units. Pore throat size determination is the main task performed by PetroFlow System, either using K/Phi relationship or any known algorithm available, as Winland or Pittman equations. Results from EPP application are used as "Input Data" for this stage, having PetroFlow System (PFS_1.0) (Figure 5) to generate flow units by automatically detect pore throat contrasts and rank them according to Rock Quality Index, which is mainly based on routine core analysis, K/Phi ratio, also known as "Speed Delivery" and dominant Pore Geometry estimations. (Figure 6).

3. Producible Fluids Saturation. This work consisted of a software development for the determination and hierarchization of flow units, based on rock quality indices and saturation of producible fluids in hydrocarbon reservoirs. Figure 7. Pertinent Data from key wells in well files, final reports and data from specialized laboratories were used for the development of this study, such as porosities, fluid saturations, capillary pressures, absolute and relative permeabilities, Rock Types, and fluid viscosities, in order to make the appropriate selection of input parameters for the project dBase, allowing to efficiently generate and rank the flow units.

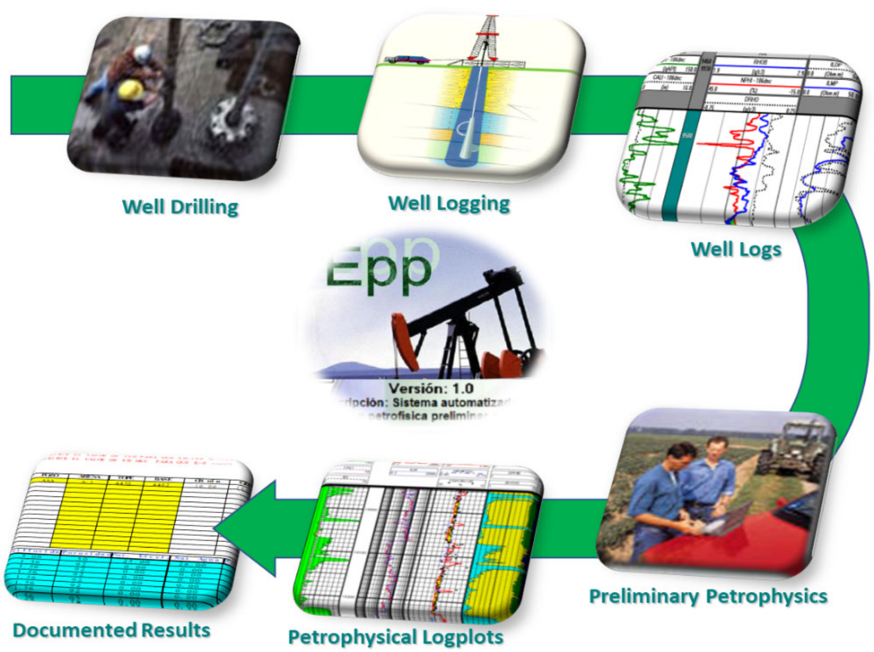


Figure 4. EPP Workflow for Preliminary Petrophysical Evaluations.

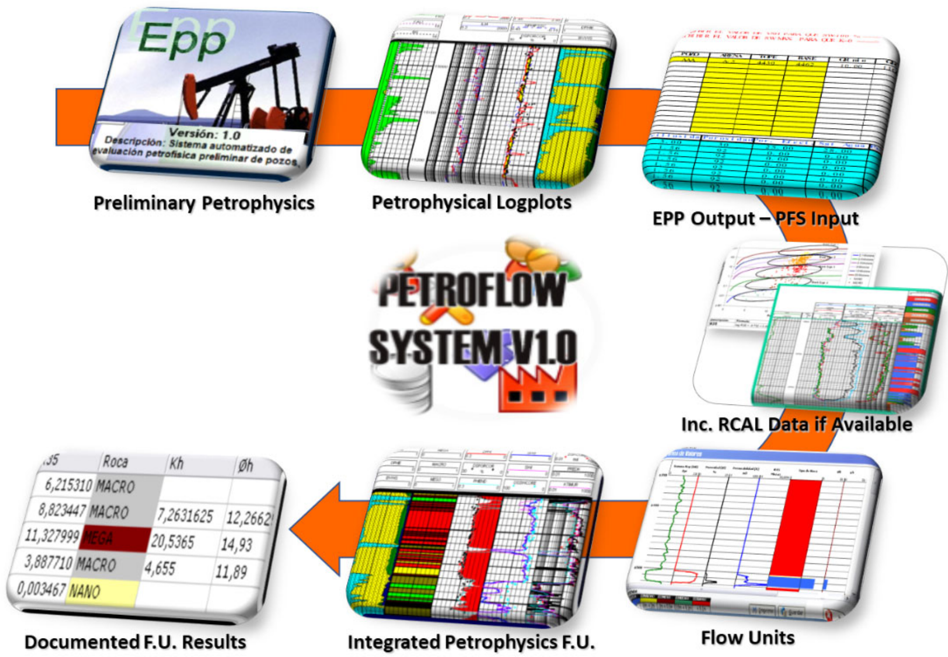


Figure 5. PetroFlow System (PFS) Workflow for Flow Unit Identification.

capillary pressures. Additionally, the studied reservoir is (at the time of the evaluation) in a state of sub-saturation, that is, whose pressure has not yet reached saturation pressure and there is no free gas. Key wells have been evaluated using the PetroFlow System 1.0 software, of which classification of flow units has been obtained according to the pore throat radius (Winland R35); considering that said, wells belong to the studied reservoir, would comply with the previous requirement, which would have drilled & cored different rock types (Megaporous, Macroporous, Mesoporous, Microporous, Nanoporous). For the purposes of developing the Workflow, the patterns of nanoporous rocks are also considered, however this work does not include this rock type for producible fluids saturation because they are not considered "Reservoir Rocks", at least in conventional reservoirs as the ones studied here.

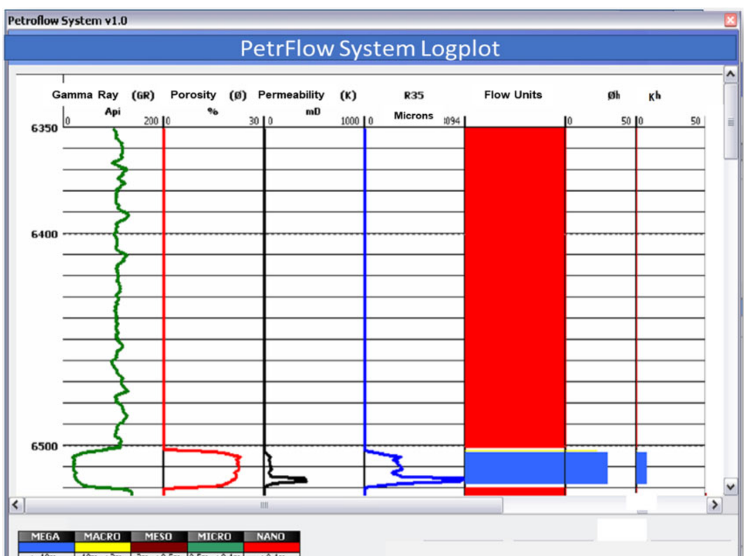


Figure 6. Automated Flow Unit Identification by detecting Pore throat size contrasts using PFS.

SFP Workflow was based on Well data provided by INTER-ROCK's internal Rock Catalogue. Selected Wells for this study were assigned the names: "P01, P02…." and the subsequent studied flow units are represented with the letter "B" followed by a two-digit integer between 01 and 07, for example: "B01" and so on; the numbering depending on the number of flow units studied, having a maximum of 7 flow units for the selected wells, representing different Rock Types according to either quality index or pore throat radius. The required data comes basically from two sources: 1.- PetroFlow System 1.0, from which the following were used: depths, average formation water saturations and Rock Type classification (K/Phi or Winland R35), and 2.- Special Core Analysis: absolute and relative permeabilities and

Methodology

Regarding the Data Review & Analysis: the data provided by PetroFlow System 1.0 outputs, have already been refined and validated as part of the previous workflow, where complete dB QC was performed on Cores, Logs and Production data; however, new lab data considered for Producible Fluids Workflow (SFP) required review and QC as well. It was mainly based on Routine Core Analysis (RCAL), Oil – Water relative permeability and Capillary Pressure curves on selected cores according to diverse Rock Types (Pore Geometry); in order to definitely select and classify the proper set of curves honoring the typical behavior for each rock quality along with the Production Data which consisted of mainly Initial Well Tests.

Relative Permeability Curves were selected at the beginning of this stage; there were twenty (20) different core samples that fully complied with the selected parameters. The 20 samples belonged to different depths and rock qualities, honoring the five (5) rock types considered for this study. Specifically, Mega, Macro, Meso, Micro and Nanoporous rocks. To achieve the successful selection of the relative permeability curves, all the curves were grouped in order to compare their behaviors. Figure 8.

Subsequently, the Krw and Kro curves are classified according to the Dominant Pore throat size of each sample, applying Winland R35 method. Once the curves have been grouped according to their dominant pore throat size, it was selected a typical curve by rock Type, which in some way represents the group of the "rock type" it belongs to. This selection was made by grouping the curves belonging to a specific Rock Type category from available core laboratory tests and Winland R-35 method at certain depths, choosing the curve that best represents the pattern of all analyzed curves. For this specific case, it should be noted that this selection was not made for mesoporous and microporous rocks because there was only one (01) of each rock type. Figure 9.

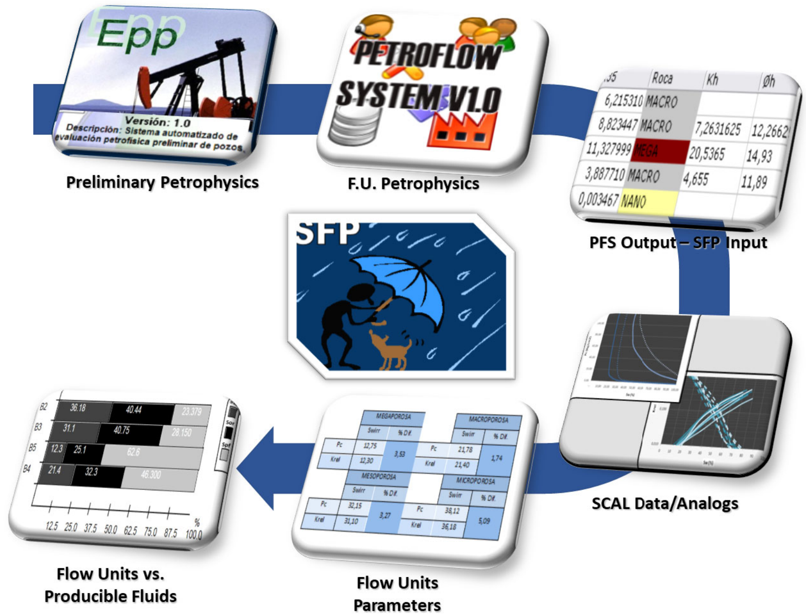


Figure 7. Producible Fluids Saturation (SFP) Workflow. Flow Units Ranking based on Rock Quality and Producible Fluids.

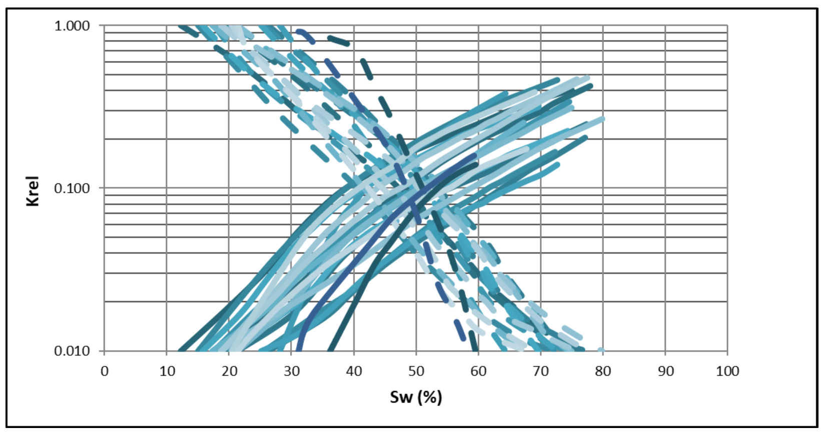


Figure 8. Krw and Kro curves from selected Core Samples. (Laboratory Data).

Capillary Pressure Curves from Special Core tests were selected. It was possible to have one representative curve for each Rock Type in a similar way it was done with Relative permeability curves. The definitive Capillary pressure curves corresponded to the same samples previously selected for Relative Permeability, so the analysis was consistent; that is, once the core that best represents the behavior of the other curves belonging to a given rock type has been selected and relative permeability curves have been analyzed, then capillary pressure curves were selected according to the same source/sample of available core. As seen in figure 10 and figure 11, one capillary pressure and Incremental Saturation curves honor each Rock Type considered for this study.

Once the curves that best honored the mega, macro, meso and microporous rock patterns had been selected, the irreducible water saturation (Swirr) values obtained by the relative permeability and capillary pressure curves for each rock type were compared; in order to establish a good "quality control". Swirr differences in all cases were below 5.1% (Table I); which was considered a technically acceptable value, having in mind that they were obtained from laboratory studies that were performed in different ways and under different conditions.

The objective of Flow Units Ranking according to producible fluids starts with obtaining irreducible water & residual oil saturations from relative permeability tests and Fractional Flow calculations. For this, 0.85 Cp and 1.95 Cp viscosity values were used for Water and Oil respectively. During this stage, required logic and mathematics were implemented through a process that allowed to determine irreducible water and residual oil saturations, which by difference provided values of movable or producible fluid satura-

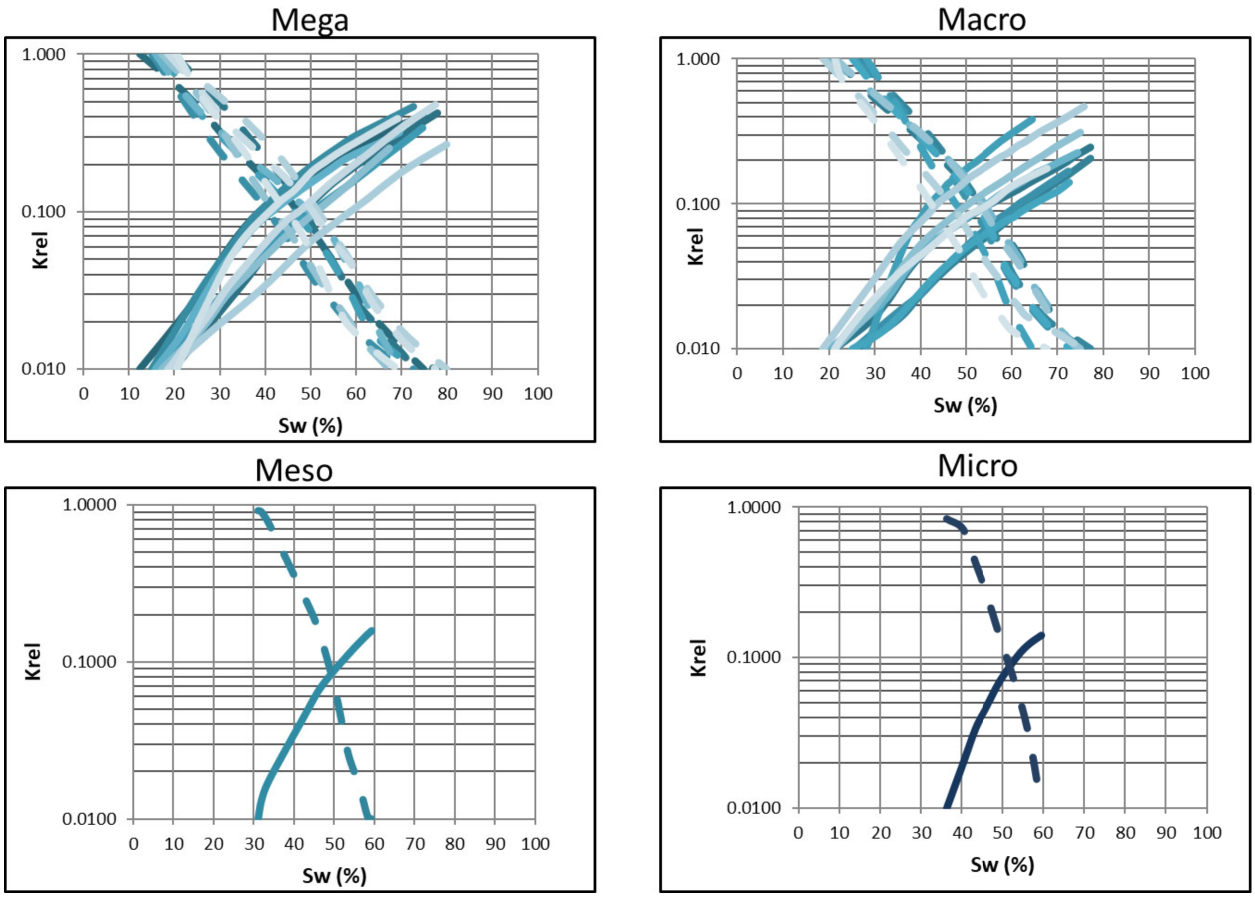


Figure 9. Oil-Water relative permeability curves set from selected Core Samples & classified by rock type. (Laboratory Data). (Megaporous, macroporous, mesoporous and microporous).

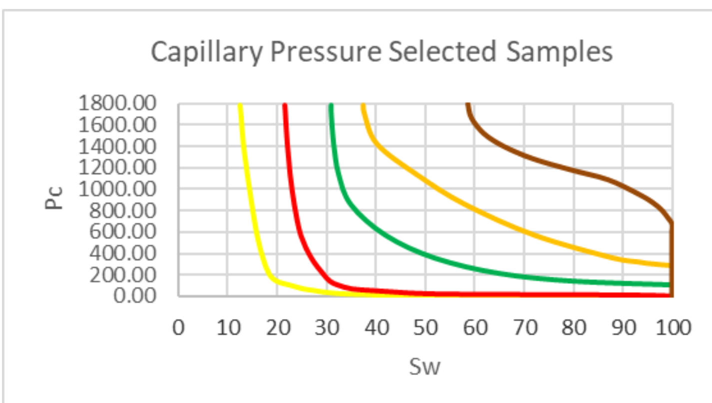


Figure 10. High Pressure Mercury Injection Capillary Pressure vs Pseudo Water Saturation curves selected from available Core Samples & classified by rock type. These curves correspond to the representative samples by Rock Type (Laboratory Data). (B6-Megaporous "yellow", B5-Macroporous "red", B3-Mesoporous "green", B2-Microporous "orange" and B1-Nanoporous "brown").

tions as well as the fluids percentages flowing in the porous media at certain values of water saturation using the following equation:

$$fw = \frac{1}{1 + \frac{Kro}{Krw} \times \frac{\mu w}{\mu o}}$$

Then, it was possible to rank flow units by producible fluids proportion, where Relative Permeability, capillary pressure and fractional flow charts classified by rock type were used in the present work. A matrix was built to illustrate the rock quality variation of representative samples from conventional and special core analysis. The shown matrix in figure 12 has four lines and four columns and it's possible to observe a single property variation along the lines and the different tests results representation along the columns. First Line shows porosity-permeability relationship variation, second line shows capillary pressure tests, third line shows relative permeability tests and fourth line the resulting calculation of Fractional Flow. Columns from left to right show tests variations for B6, B5, B3 & B2 samples respectively.

The saturation of producible fluids is obtained based on the physical principle that the sum of the volumes of fluids that occupy a given space is equal to unity or 100%; Therefore, when subtracting the sum of the irreducible water saturation and residual oil to unity or to 100%, a resultant percentage of fluid that, from a petrophysical point of view, would have

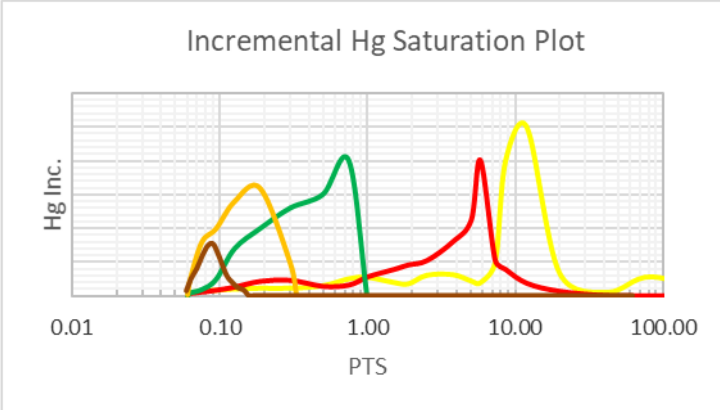


Figure 11. Incremental Saturation curves derived from High Pressure Mercury Injection tests vs Pore Throat Size selected from available Core Samples & classified by rock type. These curves correspond to the previously selected Relative Permeability samples (Laboratory Data). (B6-Megaporous "yellow", B5-Macroporous "red", B3-Mesoporous "green", B2-Microporous "orange" and B1-Nanoporous "brown").

Table I. Difference in Percentage between Swirr obtained from Relative Permeability Curves and Capillary Pressure Curves by Rock Type. ("Reservoir Rocks" from Laboratory Data). Mega porous (B6), Macroporous (B5), Mesoporous (B3) and Microporous (B2).

B6	Megaporous		B5	Macroporous	
	Swirr	% Dif.		Swirr	% Dif.
Pc	12,75	3,53	Pc	21,78	1,74
Krel	12,30		Krel	21,40	
B3	**Mesoporous**		**B2**	**Microporous**	
	Swirr	% Dif.		Swirr	% Dif.
Pc	32,15	3,27	Pc	38,12	5,09
Krel	31,10		Krel	36,18	

no restriction from being produced, will be called "saturation of producible fluids" in the present work; that is, the percentage that can be extracted from the porous media using either current methods or future technology. Once producible fluids have been quantified, these are ranked considering the reservoir water saturation at the time of the study (referred to, in the present work, as "current water saturation"), provided by the output data of previous PetroFlow System 1.0 workflow, which uses current available Well Logs and Well production Tests. When comparing the percentage of irreducible water saturation with the percentage of "current water saturation", movable water saturation is obtained by difference. For this model, oil-water relative permeabilities were used and compared at "current water saturation". Once fractional flow of water was obtained, "movable" water and oil proportions are discretized in the percentage of fluids that are produced or will be produced when the test has been stabilized. This is achieved because the value obtained from the fractional flow of water represents the percentage of producible water that is able to flow through the pore space, from which an approximate percentage of oil in motion can be obtained by difference, having in mind that the sum of both percentages must be equal to 100% "producible fluids". Subsequently, the flow units are ranked according to rock quality indices and saturation of producible fluids, considering the existing fluid saturations at the time of the study as well. The ranking process is performed by classifying flow units with the highest proportion of producible fluids in descending order. Figure 13.

Having discarded the Nanoporous rock sample that represented the quality of B1, B4 & B7 Units, since they were not considered "Reservoir Rock", the remaining units were ranked according to the resulting proportion of producible fluids, being classified in descending order, as shown in figure 13. The B6-Megaporous unit with 62.60% of producible fluids, 46.30% the B5-Macroporous Unit, 28.15% the B3-Mesoporous unit and finally the B2-Microporous unit with 23.37%.

It is important to mention that this "SFP" workflow required some specifications for analyzing, understanding and coding the system. "SFP" Software was designed considering it as a theoretical-practical tool, which was based on Object Oriented Methodology (OOM) using Unified Modeling Language (UML). The user can enter the system with the information of the client, the well and/or the well samples. Additionally, the User can modify the data of a client, a well or a sample, to adapt it to the needs of the system and/or report. When user needs to consult data, the operator can consult the data of one or more client/projects/reports as well as Synchronize the system data contained in a laptop to the main server of the company. Finally, Flow Units Ranking are based on Saturation of Producible Fluids; in this case, the User requests the system to rank the flow units to the percentage of producible fluids according to the flowchart below. Figure 14.

The Integrated Workflow. The results can be affected by uncertainty due to data from the laboratory, due to the difference between volumes measured at the surface and in depth directly from the reservoir, fractures or conning. Nevertheless, all steps in this workflow have been carefully handled to low the model uncertainty as much as possible, following strict protocols from lab to calculations.

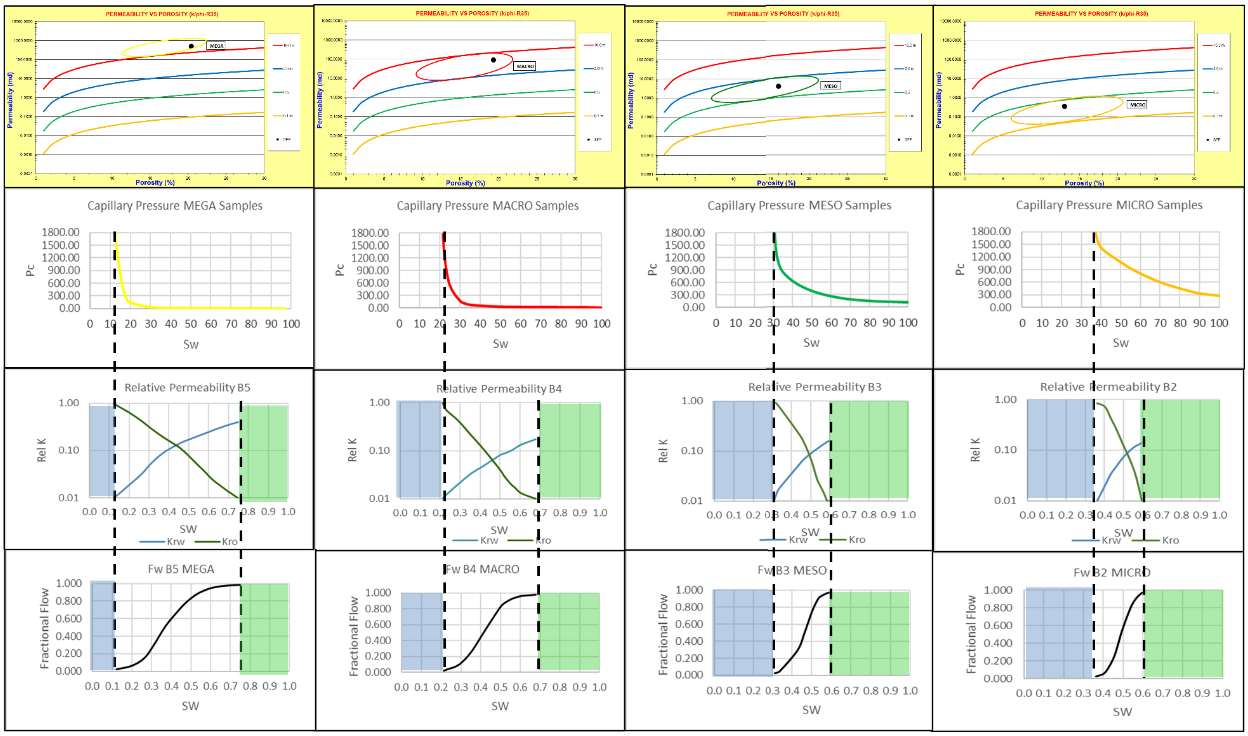


Figure 12. Characterization matrix by Rock Type from conventional and special core analysis. Blue square areas from Left Side of Rel-Perm & Fractional Flow Charts tends to represent Swirr, while Green square areas on the right side of Rel-Perm & Fractional Flow Charts tends to represent Sor.

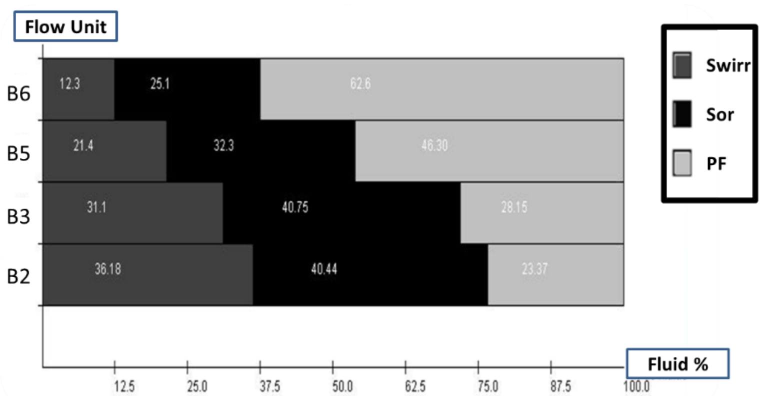


Figure 13. Flow Unit Ranking according to "Producible Fluids" (PF).

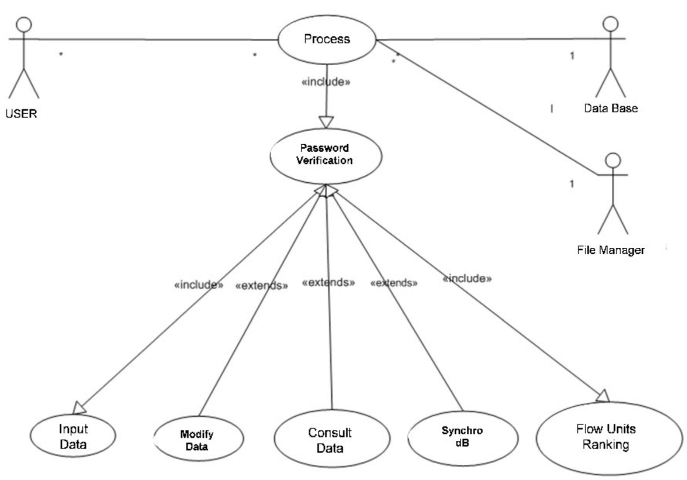


Figure 14. User Initialization & Software Process for "SFP".

The Producible Fluids Saturations system (S.F.P.), by its acronym in Spanish, has been integrated into previous workflows developed by Inter-Rock, such as Preliminary Petrophysical Evaluations (E.P.P.), by its acronym in Spanish, and PetroFlow System (P.F.S.) in order to have an express procedure that allows not only to calculate petrophysical properties and determine flow units based on pore throat sizes, but also be able to rank flow units according to their rock quality and the Oil-water Ratio of "producible fluids". For this, it was necessary to have good quality well logs and both, conventional and special core analysis. Among the main advantages of the integration of these workflows are the optimization of the turnaround times of the processes and the efficient use of resources. It is important to highlight that this process has been supported by available laboratory data even though it could have been performed using analogs from inter-Rock's catalog of rock sample analysis depending upon the characteristics of the reservoirs to be studied. In this case, it has been possible to hierarchize Flow Units not only by their rock quality, but also by the proportion of movable fluids, including Oil-water ratio of producible Fluids, resulting in an Integral workflow that we have called "Saturation of Producible Hydrocarbons" (S.H.P.), by its acronym in Spanish. Figure 15

It's very important to characterize in detail the reservoir quality by formation. That's why Capillary pressure is a very valuable test to count on because you would know the current water saturation at any stage of reservoir depletion, so you can determine original oil water contact and current oil water contact, or if it is thought that deterministic water saturation is right, then the hydrocarbon-water contact can be inferred.

Figure 16 shows the resulting Flow Unit Characterization spreadsheet based on numerical analysis according to producing hydrocarbon criteria. It is important to mention that, in a prediction exercise the hydrocarbon fractional flow for Mega & Macroporous Rocks tends to equal to about 17% when Sw = 50%.

As a result of this automated unit ranking Workflow, figure 17 shows four hierarchized flow units of different rock quality and different producible hydrocarbon percentage. Having discarded the non "Reservoir Rock", (Nanoporous B1 Unit), the remaining units were ranked according to the resulting proportion of Theoretical Oil-water Ratio (producible hydrocarbons), being classified in descending order. The B2-Microporous unit with 97.3%, the B3-Mesoporous unit with 96.8%, the B5-Macroporous Unit with 90.2% and finally the B6-Megaporous unit with 84.9%.

Results were documented in a report and after that, Inter-Rock Technical Department was in charge of making the comparison with production tests data, obtaining quite acceptable results

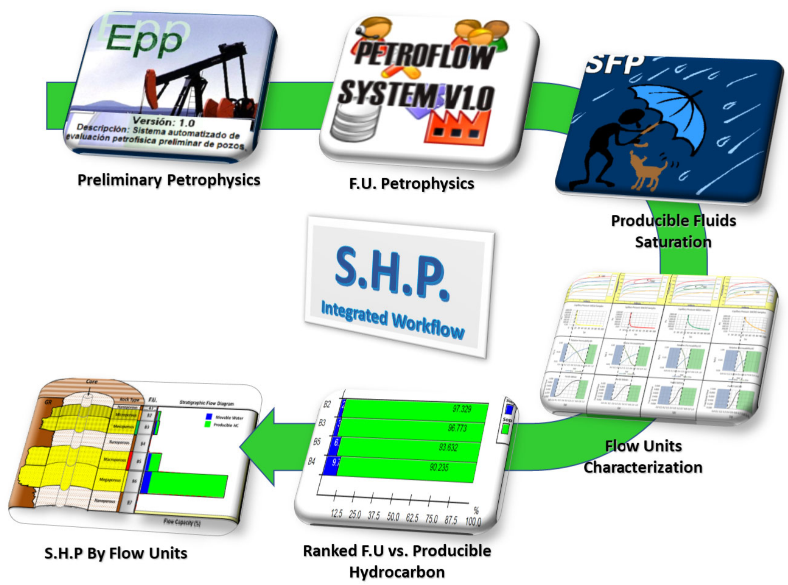


Figure 15. Producible Hydrocarbon Saturation (SHP) Workflow.

Flow Unit	Φ	K	PTS	Rock Type	Swirr	Sor	Residual Fluids	Prod Fluids	Current Sw	Fw @ Current Sw	Prod. HC @ Current Sw	Fw @ 50% Sw	Prod. HC @ 50% Sw
B2	13	0.600	0.4	MICRO	36.2	40.5	76.7	23.3	38	2.7	97.3	54.7	45.3
B3	16	4.000	1	MESO	31.1	40.8	71.9	28.1	32	3.2	96.8	75.1	24.9
B5	19.3	93.00	6	MACRO	21.4	32.3	53.7	46.3	29	9.8	90.2	82.4	17.6
B6	20.4	510.0	15	MEGA	12.3	25.1	37.4	62.6	26	15.1	84.9	82.9	17.1

Figure 16. Processed and Ranked Flow Units by "Producible Hydrocarbons" after Numerical Analysis highlighting Current Sw (Blue), Producible Hydrocarbons @ Current Sw (Green) and Forecasting Producible Hydrocarbons @ Sw=50% (Yellow).

Description for columns is as follows:
Flow Unit: selected flow Units with assigned codes; Φ: Calibrated Avg. porosity with core data; K: Calibrated Avg. permeability with core data; PTS: Avg. Pore throat size calculated from Winland R35; Rock Type: Rock quality classification according to dominant pore throat size; Swirr: Irreducible water saturation from special core analysis; Sor: Residual oil saturation from special core analysis; Residual Fluids: Non-movable Fluids (Swirr + Sor) from Rel-Perm & Fractional Flow by Rock Type; Prod Fluids: Producible Fluids Saturation. (Movable Fluids from Relative Permeability Tests); Current Sw: Current Sw from log analysis on control wells & production monitoring; Fw @ Current Sw: Fractional Flow of water at current Sw; Prod. HC @ Current Sw: Fractional Flow of hydrocarbon at current Sw; Fw @ 50% Sw: Prediction of Fractional Flow of water at Sw = 50%; Prod. HC @ 50% Sw: Prediction of Fractional Flow of hydrocarbon at Sw = 50%.

with very little differences considering the following aspects:

- The information used by the designed tool comes partially from laboratory analysis and although they optimally simulate the reservoir conditions, there might be often a margin of error, which undoubtedly affects any subsequent analysis.
- The aforementioned production tests offer volumes of fluids measured on the surface, which undoubtedly present differences with the volumes that are (at the same date) being contributed by the studied formation, this is due to the fact that in the journey inside the well (from the reservoir face to the surface) a series of phenomena are evidenced such as reservoir damage (variable degree), energy losses (pressure drops) and subsequent compositional variations and/or phase changes; which in one way or another interact in the fluid directly

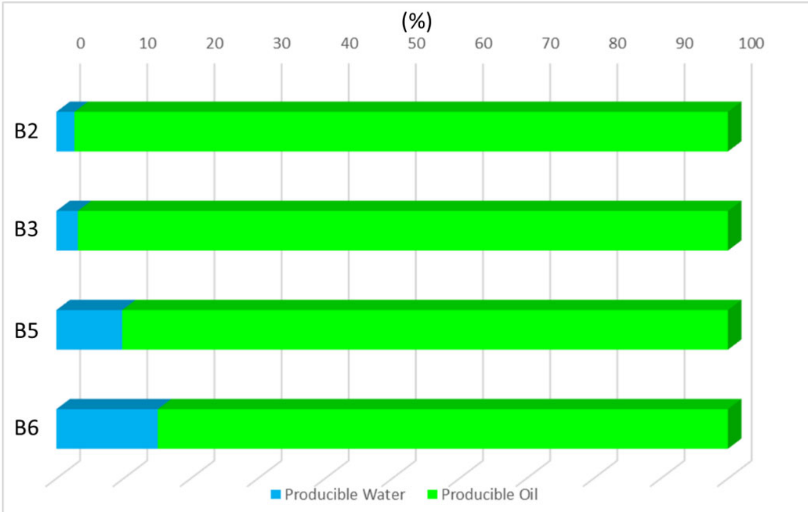


Figure 17. Flow Units Ranking according to Theoretical Oil-water ratio.

affecting the production measured at the surface; generating differences with the estimated flow capacity by the developed tool which would represent the flow at reservoir level.

- In some cases, two or more layers are producing "in comingle" so the percentages of fluid obtained at reservoir level are estimated through mathematical applications and well tests, which will hopefully contribute to reduce of the error margin.
- This work was done at matrix level, so if fractures and water coning are present, there will be uncertainty generating differences between the obtained results and the real values.

Likewise, it is important to emphasize that the obtained results are determined at a certain reservoir production stage (at the time of the study) so they vary over time, because fluids will be produced and relative permeabilities will change. The Certainty for the obtained Saturations of Producible Fluids by the designed tool was quite acceptable. Comparisons between theoretical Oil-water Ratio and real Well Tests were classified on a scale represented as follows:

a) Good (between 75% and 90% of the Well Test Production report)

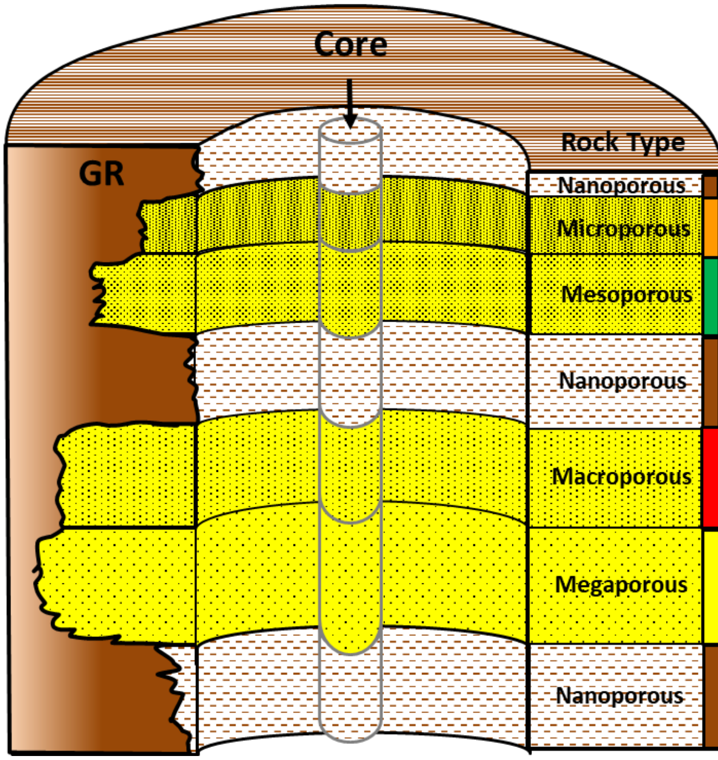
b) Very good (greater than or equal to 90% of the Well Test Production report)

The comparison between calculated and Real Oil-Water Ratios from Well Tests were observed by Rock Type. Megaporous rocks: 87% (good). In this case the % of Water was higher than expected Macroporous Rocks: 94% (very good); Mesoporous rocks: 89% (good), in this case there was some uncertainty about reservoir pressure; Microporous Rocks: (no production reported). Based on the above, it is possible to affirm that the developed tool offers good information and reasonable certainty.

Another advantage of this workflow is that it could be applicable even without having special core analysis, such as capillary pressure and relative permeability, that is, using instead, analogues, either coming from any type of catalog or from similar reservoir projects, as long as it'd be possible to account for geological nature, porosity and permeability. This implies classifying the rock types and finding the right analog or the model to compare most accurately the flow units that represent better the reservoir, that is, the best correspondence of the rock-fluid relationship. Then you can find relationships between irreducible water saturation, pore throat size or simply by comparing rock quality. It may be also a good idea to subdivide the rock quality ranges, or simply classify them by flow capacities within the same reservoir rock.

Producible Hydrocarbon Saturation (SHP) has been designed to integrate the previous EPP (Preliminary Petrophysical Evaluation), PFS (PetroFlow System) and SFP (Producible Fluids Saturation) workflows as strategical optimization to support early Well testing and completion programs. As we all know, Completion and Production programs are not done until some type of numerical prediction of production test is performed, which might include nodal analysis. In any case, this would take time before an optimized completion scheme is available. It must be borne in mind that the best quality rocks, that is, those with the highest flow capacity (Kh), will be those that will produce their content more quickly, including the water influx while in transition zone or approaching its depletion stage, for which the necessary water management resources at the surface will have to be considered. The lower the quality of the reservoir rocks, the lower its production rates, but at the same time they will retard their water production in unwanted volumes due to their moderate to low flow capacity (Kh). Communication between flow Units is another important thing to consider, as well as the hydraulic behavior regarding fluid and pressure gradients. Anyhow, it will be an economic study that finally defines what should prevail, either good hydrocarbon rates with eventual high-water influx or low hydrocarbon rates with low or no water production.

The next example shows a "Fining Upward Sequence", which gave rise to rock of various qualities. As shown in figure 18, five (5) categories of rock types from Nanoporous up to Megaporous are pres-



Rock Type	F.U.	Φ	K	Swirr	S.H.P. @ Current Sw
Nanoporous	B1	6	0.01	78.0	-
Microporous	B2	13	0.6	36.2	97.3
Mesoporous	B3	16	4.0	31.1	96.8
Nanoporous	B4	7.5	0.12	70.0	-
Macroporous	B5	19.3	93	21.4	90.2
Megaporous	B6	20.4	510	12.3	84.9
Nanoporous	B7	9.5	0.22	65.0	-

Figure 18. Characterized Fining Upward Sequence with Flow Units Numerical Analysis. Last Column Highlights Movable Fluids with "Producible Hydrocarbon Saturation" values.

ent. Coinciding, in this case, that the quality of the Rocks increases with depth. A good set of available data made possible to characterizing the flow units by integrating petrophysical properties as porosity, permeability, irreducible water saturation, and saturation of producible hydrocarbons at current water saturation. The analyzed wells were producing very little water since they were located up high in the hydrocarbon column, that is, close to irreduccible water saturation. It is expected that Reservoir rocks will increase the amount of movable water with depth, especially as the rock quality improves. Finally, this workflow will be very convenient in the application of petrophysical evaluations and flow units determination to study old and new wells where production optimization is required, either for well testing or well completion and re-completion programs. Figure 18.

The same example, but this time showing flow units storage capacity is represented in Figure 19. As can be seen in each unit, it has been possible to represent the types of fluid and their conditions with respect to mobility, that is, non-movable and "producible" fluids representing 100% of the storage capacity. Each type of rock has a different fluid distribution that depends mainly on porosity, permeability and pore throat sizes. In each of the categories of rocks present, the different proportions of movable and non-movable fluids are shown, such as: irreducible water, residual oil and, by difference, the movable fluids (water + producible hydrocarbon) based on the petrophysical characterization which uses Well Log Analysis, routine and special core analyses. In this case, a graphical method derived and modified from the flow unit profile known as "Lorenz Plot" is used to identify flow units or "Petrofacies" from the studied geological sequence. This procedure focuses on a quantitative analysis that somehow facilitates the construction of a dynamic reservoir model, as well as the possibility of grouping flow units of similar quality while still honoring the geological features of the section under study. As mentioned before, if there were no core data to calibrate parameters, this model would work effectively using analog models.

A flow unit should be understood as an interval with favorable petrophysical properties to "transmit" fluids being physically differentiable from other units based on their flow capacities. Flow units are stratigraphically mappable eventually having important variations in their lateral continuity. For this work, the flow units are considered indistinctly as "Petrofacies" or "Rock Types" which are defined as representative reservoir units with a different porosity-permeability relationship and a characteristic water saturation for a given height above the free water level. It is important to be aware about the geological context on which a study of this type is performed since the approach taken will depend on it. The geological context allows the flow units to be interpreted with-

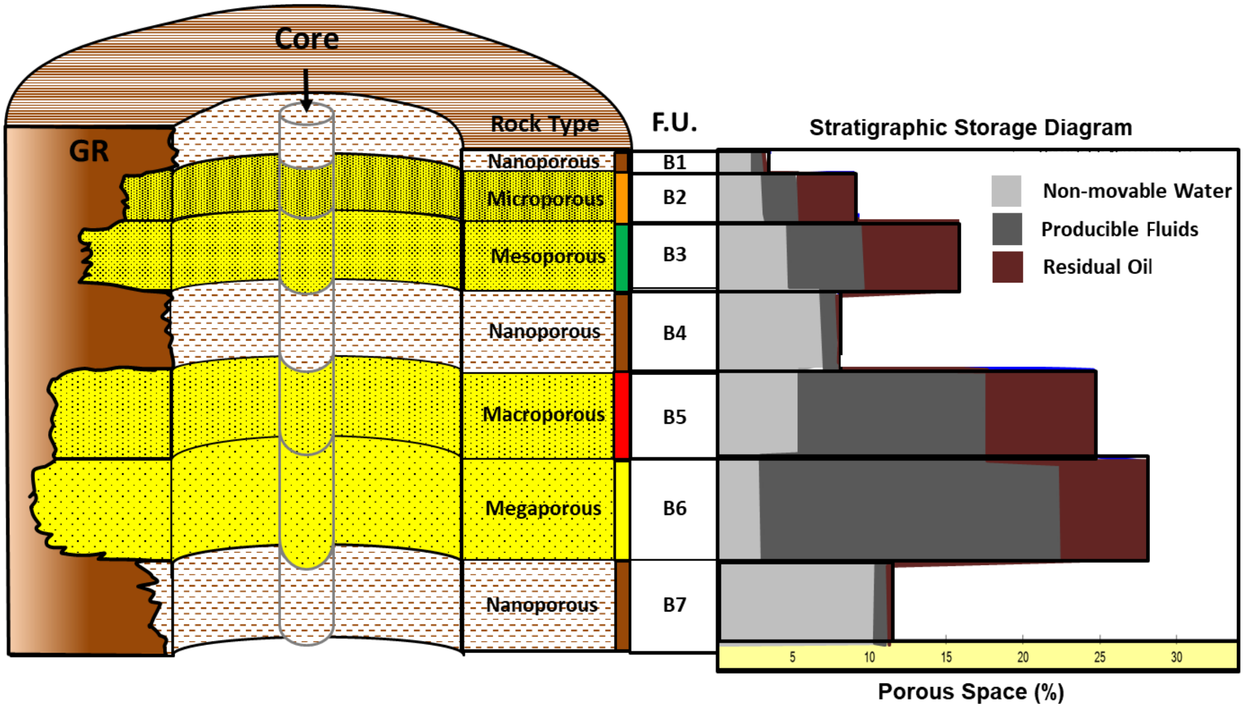


Figure 19. Characterized fining-upward geological sequence showing Storage capacity of flow units highlighting the mobility characteristics of the fluids contained in them: non-movable water, mobile fluids and residual hydrocarbon.

in a model that considers variations in rock quality, sedimentary environments and, in a way, stratigraphic sequences rather than a simple well-to-well correlation. Additionally, this procedure allows us to identify potential sealing rocks, as well as zones of excellent flow capacity, which we have called "high speed zones", which represent the best candidate units to optimize the reservoir production scheme, although on the other hand they can also generate early water breakthrough. This will depend on the hydrocarbon column height as well. This integrated method can be applied to any type of reservoir, whether consolidated or unconsolidated, siliciclastic or carbonaceous.

As explained above, this procedure attempts to provide options and more than that, tools to facilitate the numerical reservoirs simulation, as well as to support the decision-making process in both; preliminary petrophysical evaluations and early well completion programs.

In Figure 20, it is shown how this procedure also works to determine Flow capacity of the previous identified units. Each unit not only show the magnitude of its flow capacity but also the proportion of fluid type that is able to move through each unit, that is, "producible" fluids representing 100% of the flow capacity.

Conclusions

1. A detailed analysis for the needs of the proposed system was performed, including documentation of a preliminary report of hierarchical flow units based on the saturation of producible fluids.
2. The procedure used to classify flow units based on producible fluid saturations requires the intervention of multidisciplinary experts, as well as adequate and sufficient data.
3. The results obtained in this work from both, rock samples and well logs have a high level of certainty mainly due to a rigorous organization and quality control process.
4. It was possible to define an efficient model for the system database that allowed to collect properly all the pertinent information for the required documentation of the results.
5. The typical Swirr values found for the different rock types increased as a function of the decrease in the pore throat sizes.
6. The pore throat size directly affects the relative permeability of the fluids present in the porous media.
7. The determination of fractional flow of water is a very helpful tool to estimate the percentage of water production at the studied formation.
8. Viscosity and relative permeability of water and oil at a given reservoir water saturation has a direct impact on the fractional flow of water.
9. High quality Megaporous and Macroporous rocks have higher productive capacity, so their percentages of producible fluids tend to change earlier

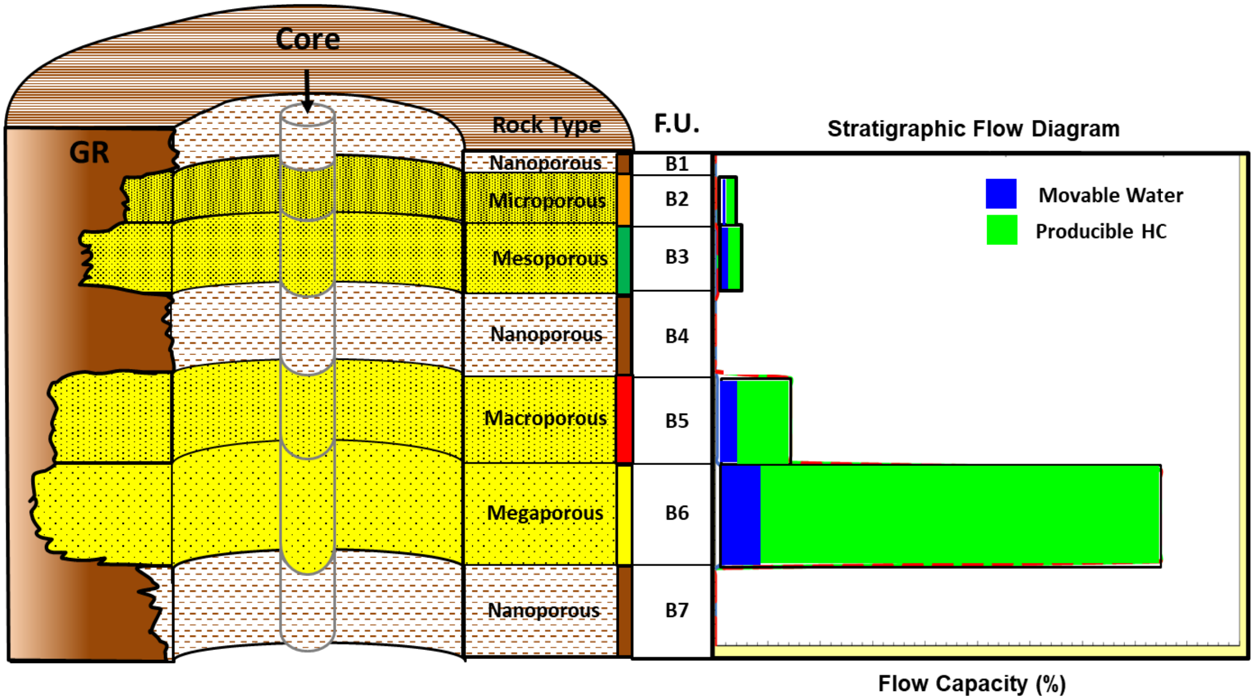


Figure 20. Characterized fining-upward geological sequence showing Stratigraphic Flow Diagram. 100% Flow Capacity of units highlighting "producible fluids" type. Movable Fluids (Water + Hydrocarbon) Flow Unit.

than those of lower quality Mesoporous and Microporous rocks.

10. The certainty of the results depends directly on the conditions under which the studied well is producing. The modules that make up the system were efficiently developed, which allowed the Integrated Workflow to generated high certainty results in a timely manner.

11. The system was designed in a simple, friendly and consistent, which made easier the system-user interaction.

12. The application of this workflow saves time to users that need to make early decisions on preliminary petrophysical evaluations and well-completion programs.

13. This Workflow can also be performed using analogs from a "sufficient Quantity & Quality Catalog Data" as long as it'll be possible to count on geological nature, fluid analysis, porosity, permeability, capillary pressure and relative permeability data.

14. Finally, it has been possible to hierarchize Flow Units not only by their rock quality, but also by the proportion of movable fluids, including water and producible hydrocarbons, resulting in an Integrated Workflow that has been called "Saturation of Producible Hydrocarbons" (S.H.P.), by its acronym in Spanish.

15. S.F.P workflow made possible to represent not only the fluid types but also their conditions with respect to mobility, that is, 100% of the storage capacity including non-movable and "producible" fluids, such as: irreducible water, residual oil and, by difference, the movable fluids (free water + producible hydrocarbon).

16. Each rock type has a different fluid distribution that depends mainly on porosity, permeability and pore throat sizes, based on the petrophysical characterization which uses Well Log Analysis, routine and special core analyses.

17. Comparisons between theoretical Oil-water Ratio from Fractional Flow estimations and real Well Tests, offered reasonable certainty since observed Well Tests by Rock Type allowed to document acceptable rate differences from the following results: Megaporous rocks: 87%, Macroporous Rocks: 94% and Mesoporous rocks: 89%.

18. Finally, S.H.P. integrated Workflow not only worked as to Flow capacity determination, but also to identify the proportion of fluid type that is able to move through each flow unit, that is, "free water" and "producible hydrocarbons" which represent 100% of the flow capacity.

Recommendations

1. Consider the versatility and easy handling of the system for studies where capillary pressure and relative permeability data are available, guaranteeing maximum accuracy in the quantification of producible fluids depending on the rock type model.

2. Apply Integrated approach in order to provide a greater degree of functionality, to search for certainty, efficiency and effectiveness of the results that are intended to obtain.

3. It'll be highly recommended to develop a further module that will allow, from this point; to determine surface production volumes; taking into con-

sideration: Decline reservoir pressure, Possible flow restrictions, Eventual damage, Energy losses in the well and any other inherent factor that affects the movement of fluids from the reservoir to the surface, in addition to the respective economic evaluation.

4. Even though this is an Inter-Rock's "Internal Routine", it is highly recommended that the User get in touch with Technology Department to go over the "user manual" before starting to apply the software.

5. In order to save time & other resources it is recommendable to apply this workflow by teams in-charge of making early decisions on preliminary petrophysical evaluations and well-completion programs.

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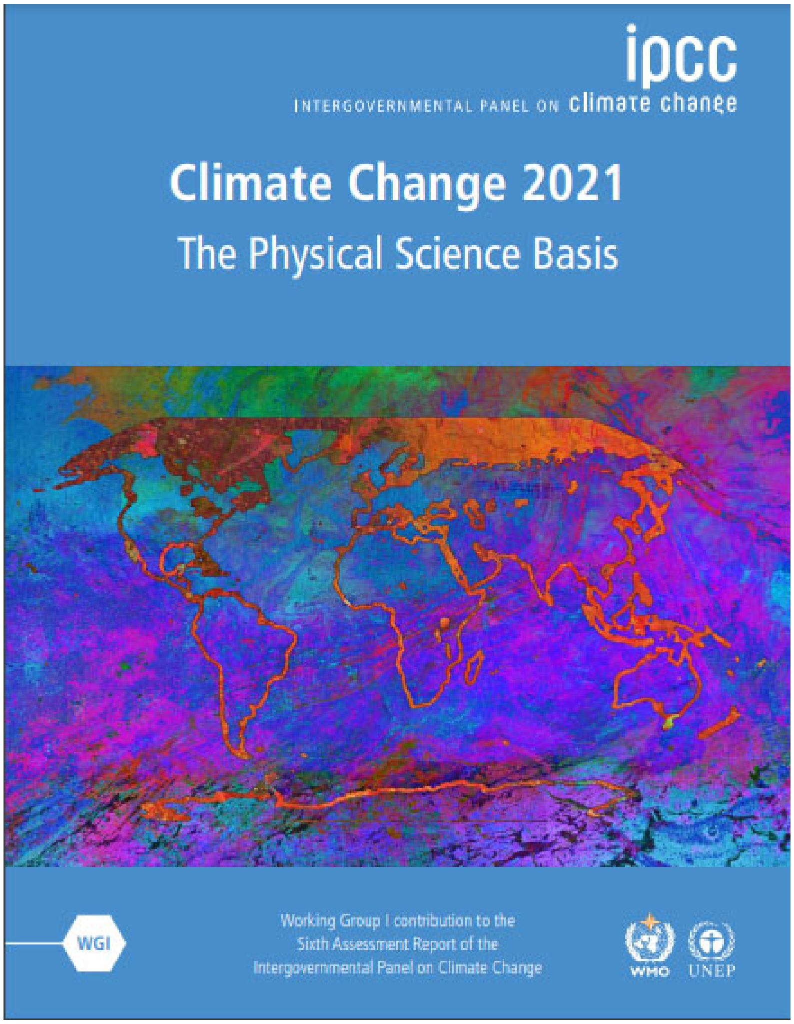

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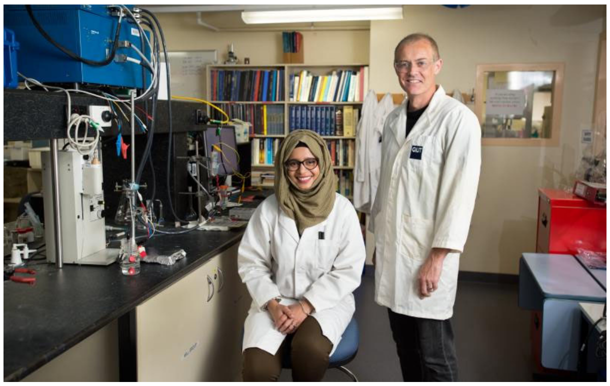
[YouTube® video] "IPCC Sixth Assessment Report - Climate Change 2021: The Physical Science Basis (Trailer)". Retrieved from: https://www.youtube.com/watch?v=I1Vx_a6F57Q&t=70s

El níquel y el cobalto permiten una producción de hidrógeno verde más barata y eficiente*



Investigadores de la Universidad de Curtin han identificado un electrocatalizador que, con níquel y cobalto añadidos, produce hidrógeno verde a partir del agua de forma más barata y eficiente que los métodos tradicionales.

El hidrógeno verde es un combustible con cero emisiones de carbono que se obtiene por electrólisis utilizando energía renovable para dividir el agua en hidrógeno y oxígeno.

Normalmente, los científicos han utilizado catalizadores de metales preciosos, como el platino, para acelerar la reacción de división del agua en hidrógeno y oxígeno, pero el equipo de Curtin descubrió que añadiendo los metales de las pilas a catalizadores más baratos, podían mejorar su rendimiento, lo que reduce la energía necesaria para dividir el agua y aumenta el rendimiento del hidrógeno.

"En nuestra investigación tomamos nanocristales bidimensionales de hierro y azufre, que no suelen funcionar como catalizadores para la reacción eléctrica que obtiene el hidrógeno del agua, y les añadimos pequeñas cantidades de iones de níquel y cobalto", explica Guohua Jia, investigador principal, en un comunicado de prensa. "Cuando hicimos esto se transformó por completo el hierro-azufre de bajo rendimiento en un catalizador viable y eficiente".

Según Jia, el uso de estos materiales más abundantes es más barato y eficiente que el actual material de referencia, el óxido de rutenio, que se deriva del elemento rutenio y es caro.

"Nuestros hallazgos no sólo amplían la 'paleta' existente de posibles combinaciones de partículas, sino que introducen un nuevo y eficiente catalizador que puede ser útil en otras aplicaciones", dijo Jia. "También abren nuevas vías para futuras investigaciones en el sector energético, lo que sitúa a Australia en la vanguardia de la investigación y las aplicaciones de las energías renovables y limpias".

En la actualidad, el 21% de la energía australiana se produce a partir de energías renovables, una realidad que muchos ven como una oportunidad, entre ellos el magnate minero Andrew Forrest.

Forrest pretende que su grupo Fortescue Metals sea neutro en emisiones de carbono para 2030, y el hidrógeno verde es uno de los principales objetivos de la empresa.

El multimillonario cree que el hidrógeno verde podría suministrar una cuarta parte de la energía mundial en 2050 y ha viajado por todo el mundo para promover esta idea.

* https://www.worldenergytrade.com/energias-alternativas/investigacion/el-niquel-y-el-cobalto-permiten-una-produccion-de-hidrogeno-verde-mas-barata-y-eficiente

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El trabajo deberá contar, como mínimo, con resumen en español y en inglés, de extensión no mayor de 250 palabras; ambos deben describir brevemente, en un sólo párrafo, el objetivo general, la metodología más relevante, resultado principal y la conclusión más importante.

Deben incluirse 5 palabras clave, tanto en español como en portugués y en inglés. Los tra-

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Devem ser incluído 5 palavras-chave, tanto em espanhol como em português e em inglês. Os trabajos deberán contar con, por lo menos, las siguientes secciones: Introducción, Planteamiento del problema o hipótesis, Metodología, Resultados, Discusión, Conclusiones, Referencias.

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Las figuras se identificarán posterior a las mismas y se deberán numerar en arábigos.

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Los mapas deberán mostrar con claridad lo que se desea, por lo que se seleccionará la escala adecuada.

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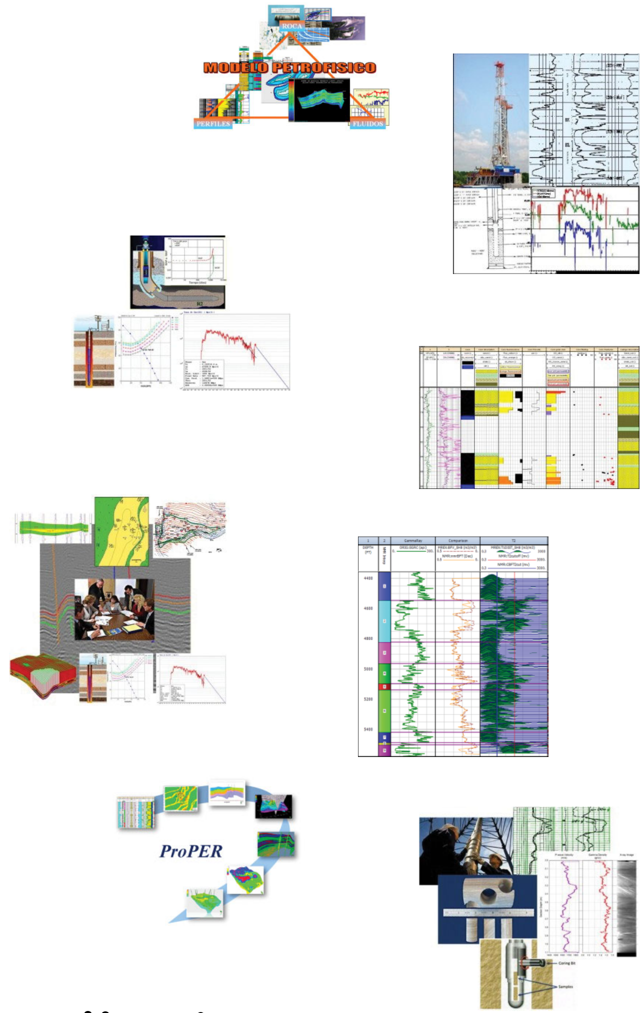

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