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□11 CONCURSOS

O Portal MundoGEO publica, toda semana, as mais recentes oportunidades de trabalho na área de geoinformação. São empregos com carteira assinada, trabalhos temporários, processos seletivos, concursos públicos, licitações, estágios e programas de trainee.

Empregos

Cargos:
1) Assistente comercial. Experiência em vendas na área de geotecnologia, conhecimento do pacote Office, atendimento ao cliente.
2) Assistente comercial. Vaga para profissionais do sexo feminino de nível médio. Necessário conhecimento em informática e microsoft office, experiência em proposta comercial preferenciamente na área de engenharia e serviços técnicos e atendimento a clientes.
Empresa: Senografia Sensoriamento Remoto Ltda.
Local: Curitiba (PR)
Contato: Enviar currículo com pretensão salarial para tania@senografia.com.br, informando no assunto do email o cargo.

Cargo: Topógrafo II. Experiência comprovada na função; Experiência em obras de Vias de Comunicação (Terraplenagem e Pavimentação);
•Domínio do Office; Domínio de GPS e Estação Total; Facilidade de adaptação a contextos multiculturais; Disponibilidade Imediata.
Empresa: Empresa de Construção e Engenharia especializada em Obras Públicas
Local: Angola
Contato: Cadastrar currículo no site: http://www.zagope.pt/

Cargo: Topógrafo supervisor. Atividades: Coordenar equipes de topografia; Definição de metas de produtividade diária; Definição de metodologia de trabalho; Realizar levantamentos topográficos gerais; Realizar controle dos dados topográficos levantados. Requisitos:
Amplos conhecimentos com levantamento planimétrico, levantamento planialtimétrico, locações, cálculos de coordenadas, transporte de coordenadas; Nivelamentos geométricos; Topografia de precisão; Experiência em mineração. Habilidades: Coordenação de equipes;
Conhecimento técnico e prático em topografia; Conhecimento total de equipamentos de topografia, principalmente Estação Total; Habilidades para descarregar e carregar dados nos equipamentos de topografia. Necessária disponibilidade para realizar viagens.
Empresa: Empresa de Engenharia
Local: Caete (MG)
Contato: Enviar currículo com pretensão salarial para rh@ergbh.com.br, informando o nome do cargo no campo assunto.

Cargo: Analista de Geoprocessamento Pleno. Necessário: curso superior completo em Geografia ou Cartografia; Experiência com a ferramenta GIS, ARCVIEW, AUTO CAD MAP ou GEOMÍDIA. Atuar na condução de projeto de geoprocessamento em conjunto com a equipe de desenvolvimento. Conhecimento em modelagem de dados. Necessário morar em São Paulo
Empresa: GEMPI Gestão Empresarial e Informática Ltda
Local: São Paulo (SP)
Contato: Enviar currículo com pretensão salarial para rh@gempi.com.br

Cargo: Profissionais com formação superior em Análise de Sistemas/Marketing/administração e afins, conhecimento do mercado TI, conhecimento em GIS e Mapeamento é um diferencial. Necessário disponibilidade para viagens e fixar residência Porto Alegre. Desejável experiência na área de desenvolvimento de negócios em TI , desenvolvimento de produtos e serviços, identificando oportunidades de novos negócios.
Empresa: Brasgeo – Soluções em geoinformação

Local: Porto Alegre (RS)
Contato: Enviar currículo para gpereira@brasgeo.com.br

Cargo: Vaga para técnico, com licenciatura em Geografia, Engenharia Geográfica ou áreas afins. Conhecimentos de software SIG; Trabalho com GPS de alta precisão; Conhecimentos de Fotointerpretação; Cartografia histórica; Arquivística; Identificação e caracterização de prédios, baldios e outras áreas cadastrais; Planejamento e realização de atividades de campo referentes à investigação geográfica. O candidato deve ser elegível no âmbito do programa de estágios profissionais do IEFP.
Empresa: Não divulgada
Local: Guimarães (Portugal)
Contato: Enviar currículo para recrutamento.gis@sapo.pt até 31 de janeiro

Cargo: Vagas são destinadas ao departamento comercial e suporte técnico da matriz em Curitiba. Desejável conhecimentos em Autocad, inglês intermediário, disponiblidade para viagens e preferencialmente possuir carteira de habilitação.
Empresa: Manfra
Local: Curitiba (PR)
Contato: Enviar currículo para rh@manfra.com.br

Cargos:
1) Analista SIG. Formação na área de informática ou áreas afins. Experiência mínima: 3 anos.Requisitos para o cargo: Conhecimentos em:
Plataforma ArcGIS avançado, ArcObjects, ArcGIS Server Banco de dados (Postgre/Postgis, Oracle), Desenvolvimento WEB, Visual Studio, C#, Java, Software livre de Geoprocessamento (GvSig e outros). Requisitos desejáveis: Autodidata, dinâmico, perfil de liderança. Áreas de atuação: Rede Elétrica, Meio Ambiente e Cartografia.
2) Engenheiro Cartógrafo. Experiência mínima: 2 anos. Conhecimentos necessários em: Tecnologia de Mapeamento a LASER. Fotogrametria Digital. Softwares: MicroStation, ArcGIS. Requisitos desejáveis: Experiência com planejamento de vôo, processamento de dados LASER. Conhecimentos em SIG Perfil autodidata e dinâmico.
Empresa: Lactec
Local: Curitiba (PR)
Contato: Enviar currículo e pretensão salarial para daniele@lactec.org.br até 04 de fevereiro.

Estágios

Cargo: Vaga de estágio para estudantes de geografia ou engenharia cartográfica. Requisitos: Conhecimento em AUTOCAD / Auxiliar de processamento digital de imagens, auxiliar de vetorização, auxiliar de criação de SIG e nas demais atividades pertinentes a área. Bolsa Auxilio: R$ 5,00 Benefícios: VT BOM RETIRO Horário: De 2ª a 6ª feira das 08:00 às 15:00 (1h de almoço).
Empresa: Não informada
Local: Curitiba (PR)
Contato: Enviar currículo para Leonardo, através do email talento@proestagios.com.br. Agendar entrevista no telefone: (41) 3029-9254.

Concursos e Processos Seletivos

Cargo: Vagas para profissionais com cuperior completo em geografia ou engenharia cartográfica ou ciência da computação e para profissionais com superior completo em geografia ou engenharia cartográfica ou geologia.
Insituição: Instituto de Pesquisas Tecnológicas – IPT
Local: São Paulo (SP)
Contato: www.vunesp.com.br

Cargo: 14 vagas para professor titular.
Insituição: Universidade Federal de Pernambuco -UFPE

Local: Recife (PE)
Contato: www.ufpe.br/proacad

Cargo: Professor Assistente. Vaga para atuação no Curso de Eng. de Agrimensura e Cartográfica. Unidade: Escola Politécnica. Departamento de Transportes. Área de Conhecimento: Topografia e Geodésia. Graduação em Engenharia. Mestrado na área do concurso (dissertação).
Insituição: Universidade Federal da Bahia – UFBA
Local: Salvador (BA)
Contato: www.concursos.ufba.br/docentes/2010/editais_docentes_2010.html

Cargo: Advogado Jr., engenheiro Jr., profissional de nível superior Jr. e técnico em hidrologia.
Insituição: Itaipu
Local: Foz do Iguaçú (PR)
Contato: www.nc.ufpr.br/concursos_externos/itaipu/2011/center_itaipu.htm

12 BOLSAS

Inpe seleciona bolsistas de pós-doutorado

O projeto "Mudança de Uso da Terra na Amazônia: Análise Institucional e Modelagem em Escalas Multitemporal e Espacial" dispõe de três bolsas de pós-doutorado para atividades no Instituto Nacional de Pesquisas Espaciais (Inpe)
Os candidatos têm até o dia 1º de março para encaminhar a documentação necessária para concorrer às bolsas, vinculadas a três subprojetos, conforme instruções nos editais disponíveis nos links abaixo.
1) Subprojeto "Identification and analysis of institutional arrangements that influence Land Use and Cover Change (LUCC) processes, using social sciences institutional analysis methods". Bolsa de pós-doutorado em análises dos arranjos institucionais que influenciam as mudanças de uso da terra na Amazônia. Edital em http://www.inpe.br/noticias/arquivos/pdf/bolsa_portugues_1.pdf
2) Subprojeto "Detection and description of occupation patterns and trajectories in multitemporal satellite data". Bolsa de pós-doutorado em Mudanças de Uso da Terra na Amazônia. Edital em http://www.inpe.br/noticias/arquivos/pdf/bolsa_portugues_2.pdf
3) Subprojeto "Construction of computational models and scenarios to represent the social interactions and institutional arrangements". Bolsa de pós-doutorado em modelos e cenários dos arranjos sociais e institucionais na Amazônia. Edital em http://www.inpe.br/noticias/arquivos/pdf/bolsa_portugues_3.pdf
(Assessoria de Comunicação do Inpe)

13 ARTIGO DA SEMANA

A mais distante das galáxias

Hubble capta estrutura a 13,2 bilhões de anos-luz, formada logo após o Big Bang
O telescópio espacial Hubble expandiu mais uma vez as fronteiras do Universo conhecido pela Humanidade. Com base em observações em infravermelho realizadas entre 2009 e 2010, astrônomos identificaram o que acreditam ser o objeto mais distante e, portanto, o mais antigo já encontrado. Batizada com a nada poética designação UDFj-39546284, a galáxia estaria a mais de 13,2 bilhões de anos-luz da Terra. Isso quer dizer que sua luz viajou 13,2 bilhões de anos até ser captada pelo telescópio.
Dessa forma, a galáxia teria se formado apenas 480 milhões de anos depois do Big Bang, a explosão que deu origem ao Universo há cerca de 13,7 bilhões de anos. Na imagem do Hubble, a nova recordista aparece como uma mancha vermelha esmaecida em meio a uma profusão de outras galáxias mais próximas da Terra.
Segundo os astrônomos Garth Illingworth e Rychard Bouwens, ambos da Universidade da Califórnia e principais autores do artigo sobre a descoberta, publicado na edição desta semana da revista "Nature", a galáxia apresenta um desvio para o vermelho de 10,3. O desvio para o
vermelho é o método usado na astronomia para calcular a distância de objetos muito afastados da Terra. Quanto maior o valor, mais distante ele está. Assim como o som da sirene de uma ambulância parece mais grave à medida que ela se afasta, as ondas da luz emitida pela galáxia foram "esticadas" rumo às faixas vermelha e infravermelha do espectro ao longo de sua viagem até o Hubble.
- É difícil acreditar que conseguimos ir tão longe e tão para trás no tempo - comenta Bouwens. - Mas não foi uma busca cega. Tínhamos razões para esperar encontrar algo assim graças à incrível capacidade dos novos instrumentos do Hubble e ao impressionante tempo de exposição utilizado (87 horas).
Em maio de 2009, astronautas da Nasa instalaram uma nova câmera no Hubble na última missão de manutenção do telescópio. O equipamento aumentou em mais de 30 vezes a capacidade do Hubble de observar galáxias com desvio para o vermelho acima de 6, quando o Universo tinha pouco menos de 1 bilhão de anos de idade. O recorde anterior de objeto mais distante captado pelo Hubble, anunciado por uma equipe de astrônomos franceses em outubro passado, era de uma galáxia a aproximadamente 13,1 bilhões de anos-luz da Terra, que se formou quando o Universo tinha por volta de 650 milhões de anos de idade.
- Estamos levando o Hubble ao seu limite - diz Illingworth. - Para ir além disso vamos precisar do telescópio espacial James Webb. Não sabemos a escala de tempo de formação das galáxias, mas provavelmente com ele poderemos ver entre 200 milhões e 300 milhões de anos após o Big Bang. São tempos cruciais para o Universo, já que acreditamos que as primeiras estrelas começaram a se formar por volta de 200 milhões de anos depois dele.
O telescópio espacial James Webb será o sucessor do Hubble, que deve continuar em operação até 2013. Previsto para ser lançado em 2014, ele terá o tamanho de uma quadra de tênis e ficará a 1,5 milhão de quilômetros da Terra, mais distante do que a Lua. Mas sua construção já começa a enfrentar obstáculos.
Inicialmente orçado em US$ 5 bilhões, o equipamento teve seus custos revistos para cima em US$ 1,5 bilhão, mas a Nasa ainda não

obteve do Congresso americano os recursos extras necessários para a conclusão do projeto.
Além de ser a mais distante, a UDFj-39546284 deu aos cientistas mais pistas sobre o processo de evolução das galáxias quando o Universo ainda era uma "criança". Estimativas baseadas em sua luminosidade indicam que a taxa de nascimento de estrelas nela é 10 vezes menor do que a observada na geração seguinte de galáxias, que inclui a recordista anterior apresentada em outubro. Segundo eles, isso quer dizer que este período de menos de 200 milhões de anos fez uma enorme diferença na evolução das galáxias e do Universo.
- A natureza das galáxias se manteve praticamente uniforme de 1 bilhão de anos depois do Big Bang para cá. Por isso é importante saber como foi o início de sua evolução para sabermos como o Universo adquiriu a estrutura atual - avalia Illingworth.
Cesar Baima, O Globo, 27/1

Paleontólogos encontram fóssil de dinossauro com apenas uma garra

Vestígios de animal foram encontrados na Mongólia Interior, na China. Espécie teria o tamanho de um papagaio
Uma equipe internacional de cientistas descobriu um fóssil de um dinossauro com apenas uma garra perto da cidade de Linhe, na Mongólia Interior, região no norte da China. O achado foi divulgado nesta segunda-feira (24) na versão digital da publicação científica "Proceedings of the National Academy of Sciences" (PNAS).
Os paleontólogos nomearam a espécie como Linhenykus monodactylus. O animal foi encontrado em rochas do Cretáceo tardio do país, formadas entre 85 milhões e 74 milhões de anos atrás. Com o tamanho de um papagaio, o organismo era carnívoro e pertence a um grupo conhecido como tetrápodes, vertebrados que usam quatro membros para locomoção.
Com os ossos da coluna vertebral, das patas dianteiras e da região pélvica desenterrados, os pesquisadores agora buscam comprender . A maior parte dos tetrápodes possui três garras em cada membro. No caso de dinossauros similares ao Linhenykus, duas delas são normalmente encontradas retraídas, apenas como pequenos resquícios dos "dedos".
Para um dos autores do estudo, o professor Michael Pittman, da College University de Londres, o exemplo da espécie descoberta na Mongólia Interior exemplifica como são complexas as modificações sofridas pelos tetrápodes no decorrer da evolução animal. A variedade vai desde cinco garras nos animais mais primitivos do grupo até duas, como no caso de tiranossauros.
O Linhenykus é a únice espécie de dinossauro com apenas uma garra, que pode ter sido usada no passado para cavar a terra em busca de insetos.
(G1, 24/1)

□14 ÍNDICE DE NOTÍCIAS

□15 AMBIENTE BRASIL

Ilhas da Papua Nova Guiné correm risco de afundar

Mudanças climáticas afetam particularmente ilhas. Muitas correm o risco de desaparecer. Com ideias criativas, moradores lutam para proteger seus territórios e se tornam peças-chave da política climática.

Groenlândia degela menos que o previsto, dizem europeus

Pesquisadores europeus realizaram um estudo, publicado na revista "Nature", em que afirmam que o degelo da ilha pode levar mais tempo do que se imaginava.

Temperatura da água no Ártico é a mais quente em 2 mil anos

Estudo calcula que houve aumento de 1,94 ºC na temperatura da água, o que altera a circulação oceânica em todo o mundo.

Clima entra na lista de discussão de Fórum Econômico em Davos

Representantes de governo e negociadores do clima vão analisar novos caminhos para as negociações sobre o clima.

Região serrana do RJ tem 8.814 desabrigados e 20.996 desalojados

O município de Teresópolis tem o maior número de desalojados e desabrigados.

Grupo mostra que medidas simples reduzem consumo de energia

As alterações em casas e edifícios incluem instalação de vidros triplos para melhorar o isolamento térmico, utilização de tampas de panelas ao cozinhar e redução da temperatura de máquinas de lavar roupa e louça, entre outras mudanças. No transporte, também é indicado que o peso dos carros seja limitado a 300 quilos.

Chuva que caiu nesta quinta-feira no Rio Grande do Sul não foi suficiente para aliviar a seca

A seca que castiga o pampa gaúcho é causada pelo fenômeno La Niña, o esfriamento do Oceano Pacífico, que altera os ventos no Continente Sul-americano e concentra a umidade em algumas regiões.

Sobe para 64 número de cidades em emergência pela chuva em SC

Quase 26 mil pessoas tiveram que deixar suas casas em todo o estado. Segundo a Defesa Civil, os temporais provocaram cinco mortes.

Nova York/EUA sofre pior nevasca da história

Esta "tempestade de inverno" bateu o recorde de intensidade, que antes era de uma registrada 140 anos atrás, e forçou a suspensão das atividades em tribunais, órgãos públicos e até na sede da ONU.

Plano da ONU para preservar tubarões é um fracasso, denunciam especialistas

Estudo divulgado nesta quinta-feira (27) culpa Indonésia, Índia, Espanha, Taiwan e outros 16 países que ocupam o topo da lista de pescadores deste peixe.

Com DNA de orangotango mapeado, cientistas querem proteger a espécie

Pesquisa identificou genoma completo do animal pela primeira vez. Espécies vivem sob pressão em habitats de origem na floresta tropical.

Acordo tenta acabar com extração ilegal de madeira em Anapu, no PA

Ibama, Incra e produtores rurais assinaram compromisso no município. Área com exploração fica em assentamento e moradores querem proteção.

Pesquisadores dos EUA descobrem possível 'cura' para diabetes tipo 1

Desativação de hormônio dispensaria injeções de insulina, dizem cientistas. Testes pré-clínicos foram feitos em camundongos.

Colômbia alerta sobre risco de erupção do Vulcão Galeras

Segundo o Instituto Colombiano de Geologia e Mineração, o risco existe em decorrência das oscilações das atividades sísmicas na região.

Países insulares buscam alternativa contra salinização de água

Arquipélagos como a Micronésia ameaçam afundar e o indício de tal risco já se vê hoje: os lençóis freáticos estão cada vez mais salgados e a água potável, limitada. Contudo, ainda há uma saída.

Rua terá obra de drenagem para evitar alagamentos em Curitiba/PR

Galerias e canais de escoamento são implantados no bairro do Ganchinho. Tubulações que escoam água de córrego também devem ser ampliadas.

MPF entra com ação contra licença do Ibama para Belo Monte

Órgão ambiental liberou instalação de canteiro de obra nesta quarta (26). Ministério Público alega que exigências ambientais não foram cumpridas.

Observatório astronômico confirma queda de meteoritos na Bahia

Fragmentos foram achados em dezembro por moradora de Feira de Santana. Astrônomo disse que é o primeiro reconhecimento oficial do fato na cidade.

Homem moderno emigrou da África há menos de 100 mil anos, diz estudo

Vestígios achados na península arábica são provas, segundo cientistas. Descoberta será divulgada na revista 'Science'.

Vulcão entra em erupção no Japão e solta fumaça a 3.000 metros

Parte da população de Miyazaki saiu da região voluntariamente, mas voltou mais tarde.

Nave-robô do Japão chega à Estação Espacial Internacional

Cargueiro leva mantimentos, equipamentos científicos e peças de reposição.

Ministério quer menos burocracia em aeroportos na hora de liberar material destinado à pesquisa

A ideia do Ministério da Ciência e Tecnologia é que profissionais treinados trabalhem nesses locais e ajudem a desburocratizar o processo de liberação do material para os pesquisadores.

Relógio biológico de todas formas de vida pode explicar doenças

Segundo os cientistas, o mecanismo que controla o relógio interno pode levar à explicação de doenças como diabete, depressão e câncer em pessoas que trabalham em regime de plantão.

A Regulamentação da Política Nacional de Resíduos Sólidos está em vigor e não pode passar despercebida. Análise Parte I

Nesta segunda parte deste esforço de desnudar a regulamentação da Política Nacional de Resíduos Sólidos (PNRS), forçosamente teremos que, antes de apresentar outros comentários, reforçar alguns anteriores.

Combate ao desmatamento deveria ser mais abrangente, diz pesquisa

Entidade diz que houve progresso limitado na proteção de florestas. Segundo ONU, mundo desmatou uma 'Grécia' por ano entre 2000 e 2009.

ONU: 373 desastres naturais mataram mais de 296 mil pessoas e custaram US$ 110 bilhões em 2010

O comando da Estratégia Internacional para a Redução de Desastres alertou que é necessário definir uma estratégia preventiva para evitar que desastres naturais provoquem mortes e danos materiais tão elevados em todo mundo.

Meteorologista diz que com novas máquinas, Brasil será país de ponta na prevenção de desastres

Marcelo Barbio Rosa, do Inpe, destacou que, se as informações não forem enviadas com qualidade, a prevenção será falha.

Sobe para 43 número de cidades em emergência pela chuva em SC

Mais de 23,2 mil pessoas tiveram de deixar suas casas no estado. Cinco pessoas morreram, segundo a Defesa Civil.

Número de desabrigados e desalojados na Região Serrana do Rio chega a 25 mil

Até o momento as autoridades contabilizaram 809 mortos e 400 pessoas continuam desaparecidas.

RS: treze municípios estão em estado de emergência por causa da seca

Algumas medidas como abastecimento de água com ajuda de caminhões-pipas e cestas básicas para as famílias afetadas já foram tomadas.

Defesa Civil monitora encostas em Itajaí, que está em estado de alerta

De acordo com o Inmet, a previsão do tempo para terça-feira (25) na região do Vale do Itajaí, em Santa Catarina, é de céu parcialmente nublado a nublado, com pancadas de chuva e trovoadas.

Fortes chuvas na Califórnia contradizem fenômeno La Niña

Padrão do fenômeno climático seria levar condições secas ao estado americano.

Termelétrica a carvão será inaugurada com promessa de não agredir ambiente

A nova usina, localizada na cidade de Candiota (RS), utiliza dessulfurizadores, uma tecnologia que reduz os impactos ambientais da termelétrica.

Macaco que mordeu 120 pessoas em 2010 escapa de reserva no Japão

Lucky era mantido em cativeiro desde outubro passado em Mishima. Funcionários públicos da cidade pedem que moradores tranquem portas.

Descoberto na China dinossauro miniatura de apenas uma garra

Os cientistas não têm certeza como os Linhenykus monodactylus evoluíram para deixar de ter dois dedos, mas segundo o estudo, "seu desaparecimento pode simplesmente refletir o fato de que não estavam mais sendo mantidos ativamente pela seleção natural".

Especialistas pedem mudança no setor alimentício para prevenir crise global

O estudo intitulado "O futuro dos alimentos e a agricultura: desafios e opções para a sustentabilidade global", foi realizado durante dois anos por 400 especialistas de 35 países, que concluem que é preciso tomar medidas urgentes para garantir uma segurança alimentar sustentável e a longo prazo.

Reflorestamento pode reduzir cólera no Haiti

Projetos para melhor uso do solo além de reduzirem risco de inundações, também garantem maior acesso à água potável.

Funai interdita área para índios isolados nas proximidades de Belo Monte, no Pará

Criação da Terra Indígena (TI) tenta proteger isolados dos impactos que deverão ser causados pela hidrelétrica na região. Seca artificial do rio e aumento substancial da invasão de terras públicas, no entanto, são problemas que ainda não têm solução.

Pesquisadores avançam nos estudos para redefinir o quilograma

Protótipo que dá base à medida teve variação de massa. Pesquisas tentam usar constante para obter valor fixo.

Prefeituras paraenses têm até o dia 31 para aderir ao pacto contra desmatamento na pecuária

Assinando o termo de ajuste de conduta, os municípios garantem mais tempo para que os criadores peçam a licença ambiental rural das propriedades.

Cargueiro com lixo da ISS volta à Terra e afunda no Pacífico

O Progress M-08M partiu de Baiknour em 27 de outubro, levando mais de 2,5 toneladas de carga para os tripulantes da Estação Espacial Internacional.

Bloquear gene 'rebelde' pode impedir câncer de se espalhar, sugere estudo

Gene 'WWP2' destrói proteína que inibe a difusão de células cancerígenas. Pesquisa foi feita pela Universidade de East Anglia, na Grã Bretanha.

Cientistas descobrem buraco negro supermassivo
Agrotóxicos comercializados no país são perigosos para o meio ambiente

Entre os riscos dos agrotóxicos para a natureza estão interferências nos processos de respiração do solo e distribuição de nutrientes, além da mortandade de espécies de aves e peixes.

Aumentam casos de dengue entre crianças e Ministério adota manual de tratamento diferenciado

De acordo com o Ministério da Saúde, o diagnóstico da dengue é difícil porque os sinais podem ser semelhantes aos de outras doenças comuns nessa faixa etária.

No Xingu, tribo kamayurá tem mulheres como pajés

As meninas ficam presas por anos nas malocas até se tornarem mulheres. Elas plantam e colhem a mandioca, base da alimentação do povo.

276 kg de pescados são apreendidos na Região Metropolitana de Belém/PA

Operação durou quatro dias e terminou nesta segunda-feira (24). Parte dos peixes apreendidos foi doada para entidades.

16 JORNAL DA CIÊNCIA

Edição 4187 - Notícias de C&T - Serviço da SBPC

1. Glauco Arbix assume presidência da Finep nesta sexta-feira
2. Deputados apontam prioridades para área de ciência e tecnologia
3. Nova diretoria da FAP do Mato Grosso do Sul é nomeada
4. Secti e UFBA buscam aprimorar políticas de C&T
5. Luiz Antonio Antoniazzi é o novo presidente da Cientec
6. A desindustrialização e o aumento da inovação, artigo de Luís Felipe Giesteira
7. A articulação entre educação e ciência e tecnologia
8. Depois dos erros, MEC vai reformular o Enem
9. A USP contra o Estado de Direito, artigo de Fábio Konder Comparato, Francisco de Oliveira, Jorge Luiz Souto Maior, Luiz Renato Martins e Paulo Arantes
10. Morre o professor da UnB Cezar Martins de Sá
11. Morre o sociólogo Daniel Bell
12. Falece Adriano Caranassios, pesquisador do Cetem
13. Organizador de livro sobre avanço da ciência vê tema como "grande ausente"
14. Sai licença para obra de Belo Monte começar
15. MMA lança roteiro para criação de unidades de conservação municipais
16. Groenlândia degela menos que o previsto
17. Estudo europeu aperfeiçoará modelos para predizer o clima, artigo de Marcelo Leite
18. Novo modo de desaparecer, artigo de Fernando Reinach
19. Estudo identifica relógio biológico de todas as formas de vida
20. A mais distante das galáxias
21. Orangotango: muito parecido com o homem
22. "Ciência Hoje On-line": Pré-vestibular na internet
23. Sarau científico no Museu da Vida/Fiocruz discute pesquisa com células-tronco
24. Ceitec SA abre processo seletivo para preenchimento de 11 vagas

Edição 4186 - Notícias de C&T - Serviço da SBPC

1. Mercadante encerra visita à Amazônia conhecendo projetos
2. Secretaria de C&T de Goiás busca parceria com governo federal e municípios
3. Secretário de C&T do Paraná discute parcerias com a secretaria de Indústria e Comércio
4. Secretário de C&T de SP conhece laboratórios do IPT
5. Diretores da Fapesp são reconduzidos
6. Andifes quer maior envolvimento das universidades federais com as políticas públicas
7. Conselheiro do CNE defende Enem regionalizado
8. Engenharia é a carreira mais visada no Sisu
9. Conselho da UnB vai discutir reestruturação do Cespe
10. AEB aprova licenciamento para atividades da Alcantara Cyclone Space
11. Obama faz apelo por união e inovação em discurso ao Congresso
12. "Nature" destaca entrada do Brasil no ESO
13. Professores de universidade gaúcha atuarão em laboratórios da Coreia
14. Vacina vegetal é criada no Brasil
15. Clima: País não conta a emissão do pré-sal
16. Efeitos climáticos de La Niña persistem até meados de 2011, diz entidade internacional
17. Fórum discute importância das florestas para sustentabilidade do planeta
18. Simulação prepara "pouso em Marte"
19. O Museu de Astronomia e Ciências Afins, artigo de Wanderley de Souza
20. Museu Goeldi recebe doação de peças marajoaras
21. Alemanha não devolverá busto de Nefertiti
22. Sinais ocultos
23. "Ciência Hoje On-line": Proteção antes e depois da infecção

24. Prorrogado o prazo de inscrições do 19º Venture Forum Finep

Edição 4185 - Notícias de C&T - Serviço da SBPC

1. Publicadas nomeações para o Ministério da Ciência e Tecnologia
2. Em Manaus, Mercadante ressalta necessidade investir mais em recursos humanos
3. Inpa integrará rede brasileira de pesquisa sobre mudanças climáticas
4. Êxito de bônus para professor divide especialistas
5. Apostas de Doha, artigo de Dilvo Ristoff
6. Pesquisadores do Tocantins reúnem-se com secretário
7. Jorge Audy assume diretoria da Anprotec
8. Embrapa vai liderar rede internacional de pesquisa em ingredientes funcionais de frutas
9. Nova espécie de planta é descoberta no Nordeste
10. Termelétrica a carvão será inaugurada com promessa de não agredir ambiente
11. EUA tentaram impedir programa brasileiro de foguetes
12. Ucrânia recorreu aos EUA por foguete com o Brasil
13. Pesquisador da UFRJ recebe prêmio internacional
14. Estudo cobra da ONU plano climático mais abrangente
15. Sputnik Redux, artigo de Esther Dyson
16. Uma decisão de peso
17. Gene que deflagra as metástases é bloqueado
18. Grafite 'curvo' é usado para controlar comportamento de elétrons
19. Paleontólogos encontram fóssil de dinossauro com apenas uma garra
20. Ciência Hoje On-line: Das estrelas ao GPS, coluna de Adilson de Oliveira
21. Nações Unidas lançam prêmio "Água para Vida"
22. Prorrogadas inscrições para a Cátedra Dra. Ruth Cardoso, na Universidade de Columbia
23. Inpe seleciona bolsistas de pós-doutorado
24. Mestrado em Engenharia Elétrica na FEI

Edição 4184 - Notícias de C&T - Serviço da SBPC

1. Mercadante quer mais interação entre as unidades de pesquisa do MCT
2. Banco Central avalia capitalização da Finep, diz Mercadante
3. Ministro da C&T se reúne com dirigentes de instituições em Manaus (AM)
4. Glaucius Oliva assume o CNPq na próxima quinta-feira
5. Novos desafios para o CNPq, artigo de Carlos Alberto Aragão de Carvalho Filho e Glaucius Oliva
6. 'Prioridade é criar um novo marco legal', entrevista com Glaucius Oliva
7. Burocracia ainda é um dos principais entraves à pesquisa científica no país
8. Brasil e Coreia acertam cooperação no estudo de políticas de CT&I
9. Dilma cobra soluções de Haddad
10. Livros para todos
11. Capes e Embrapa iniciam programa para realização de projetos conjuntos
12. Falece Luiz Andrea Favero, professor da UFRPE
13. Academia Brasileira de Ciências organiza grupo de estudos sobre desastres ambientais
14. A gênese da destruição
15. Alerta que vem da lama
16. "Ciência Hoje On-line": Fatalidade ou desleixo?
17. Ministra diz que Ibama trabalha "normalmente" com presidente substituto
18. Para desfrutar de segurança energética, artigo de Leonam dos Santos Guimarães
19. Potencial hidroelétrico não está esgotado, artigo de José Goldemberg
20. Corte universitário da Califórnia põe em risco fonte de talentos dos EUA
21. Nasa quer que internauta ache planetas
22. A essência da realidade física, artigo de Marcelo Gleiser
23. PF investiga venda ilegal de peixe ameaçado
24. USP celebra o Ano Internacional da Química com atividades em todos os campi

17 MUNDOGEO

Safe Software lança nova versão da plataforma FME
A Safe Software lançou esta semana uma nova versão de sua plataforma de transformação de dados ...

Disponível novo período para inscrição em curso da Unisinos
A Universidade do Vale do Rio dos Sinos (Unisinos) está com o segundo período de inscrições ...

Inpe obtém dados de satélites para avaliar desastre no Rio
O International Charter Space and Major Disasters, que distribui dados orbitais para auxiliar países afetados por ...

Inscrições abertas para programa de Certificação Técnica da Esri
A partir de agora, usuários dos softwares da Esri podem se inscrever para os exames do ...

Geólogos e geotécnicos são peças chave na previsão de catástrofes
A demanda por estes especialistas é grande, porém há profissionais despreparados e falta incentivo nas ...

Late Pleistocene regional extension rate derived from earthquake geology of late Quaternary faults across the Great Basin, Nevada, between 38.5{degrees}N and 40{degrees}N latitude
Rich D. Koehler and Steve G. Wesnousky
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Melanie M. Busch, J. Ramon Arrowsmith, Paul J. Umhoefer, Joshua A. Coyan, Sara J. Maloney, and Genaro Martinez Gutierrez
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Environmental geology and geohazards

Degassing of sea-floor clathrates

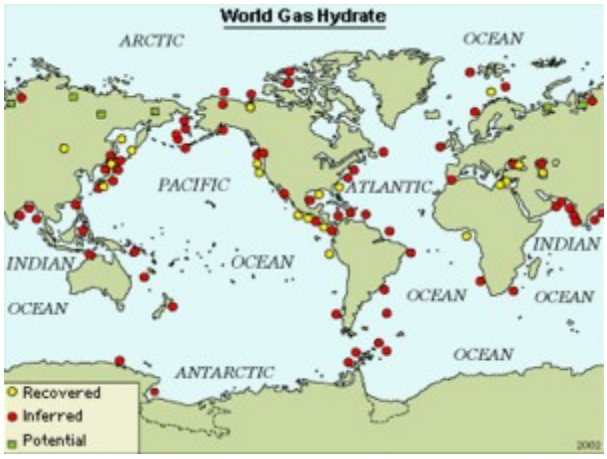

Image via Wikipedia

Methane hydrates – natural gas held in clathrate solids that resemble water ice – that occur in sea-floor sediments are on the one hand a potential energy resource and on the other pose great risks. There are between 10^{15} to 10^{17} m^3 buried beneath the ocean floors and an unknown amount in Arctic soils and lakes. The temperature that confers stability on these peculiar solids depends on pressure. At pressures lower than those at a water depth of around 250m they are unstable. Clathrate crystals form from natural gas and water in sediments at 0°C at that depth and at progressively higher temperatures at deeper levels beneath the seafloor, until geothermal heat flow at a depth of around 2.5 km results in temperatures above about 20°C when they cannot form; there is a depth-temperature window in which gas hydrates may be found in seafloor sediments, which depends on the temperature of deep water. Little is known about the stability of gas hydrates. In some areas there is a steady release of methane that bubbles to the surface, whereas in others they can be detected by seismic surveys in huge volumes that appear to be stable with no release. One area rich in gas hydrates occurs

at the continental edge off the Norwegian coast (the Storegga in Norwegian). Periodically sediments at the Storegga fail in massive sub-sea landslides which have resulted in tsunamis in the North Sea. The last such tsunami occurred around 6100 BCE after a slide displaced 3500 km^3 of debris, devastating the east coast of Scotland. Either an earthquake triggered the slide or it was due to destabilizing of the clathrates. Either way huge amounts of methane would have been released. At the end of the Palaeocene Era (55 Ma) a global carbon-isotope anomaly coincides with evidence for very rapid climatic warming, which suggests that vast amounts of methane – a far more powerful greenhouse gas than CO_2 – were released from submarine gas hydrates. In recent years the loss without trace of several large ships may have resulted from a lowering in the density of surface water by gas bubbles that caused the vessels to founder. One country that plans to exploit gas hydrates off its Pacific cast is Japan, and recent surveys indicate a large basin underlain by highly disturbed sediments which contain clathrates on the flank of the basin (Bangs, N.L. et al. 2010. Massive methane release triggered by seafloor erosion offshore southwestern Japan. Geology, v. 38, p. 1019-1022). It appears that bottom currents eroded the seafloor to destabilize the clathrates that then 'erupted' ripping through the sediments to release around 1.5×10^{11} m^3 of methane. Clearly, drilling into gas hydrate deposits is going to be a risky business; drilling will reduce the pressure so that gas is released and it is not known whether or not this might trigger a form of chain reaction. In the longer term, warming of deep water as a result of climate change could place much larger areas of clathrate-rich seafloor in a knife edge.

The anatomy of a small landslip

Posted on September 13, 2010 by linarite| Leave a comment

At the centre of the Peak District National Park in England is a small mountain called Mam Tor, at the summit of which is a large Iron Age fort complete with defensive ramparts and ditches. Complete, that is, except for its southern parts, which are chopped through by a large arcuate cliff. Below that is hummocky ground typical of landslips, but such disturbed ground is common over large tracts in the Peak District that lie below hills, especially those underlain by Lower Namurian shales of the region. Mam Tor is the only one of these that has an active landslip. Since my early childhood the local authority has tried to keep trafficable a once major road linking the cities of Sheffield and Manchester, but to no avail; most winters it was buckled and cracked by continued motion. The road was abandoned in 1979 and is now a magnificent laboratory for judging the kind of motion involved in the Mam Tor slip. The Iron Age people had much the same problem, as the slip began around 1500 BC long before the fort was built. Clearly, they were not engineering geologists, though the unclimbable scar was maybe a defensive bonus, provided the old, the bewildered and the very young were kept well away from it, as they are today.

Records of the movement have been kept since the road was constructed in 1820, and one milestone has moved 50 m in 190 years at a constant annual rate, but just how it moves has only become clear since Manchester University geologists installed tilt and creep meters, and 50 survey stations in 2004-5. Their preliminary results are just in (Green, S. et al. 2010. The effects of groundwater level and vegetaion on creep of the Mam Tor landslip. Geology Today, v. 26, p. 134-139). The creep rate is clearly governed by groundwater level beneath the slip, and has risen as high as 19.5 mm per day. From the logarithmic plot between the two variables it is possible to estimate the creep rate with completely saturated ground, which would be an ominous 0.6 m per day. Thankfully, drainage through the slip is good, as beneath lie highly unstable mudstones; but things could change. The team has also monitored local rainfall, and precipitation underwent a marked increase from 2000 onward (1.64 m per year) compared with the average since 1930 of 1.3 m per year. Fortunately, spring and summer rains are quickly returned to the atmosphere by vigorous evapotranspiration by the lush grasses and ferns on the slipped mass. The greatest creep takes place in the winter when vegetation has died back. Mam Tor is indeed highly instructive, but at present poses no great hazard, yet it might become less predictable should annual rainfall increase. It is unlikely to attain the awesome pace of that in Calabria, southern Itaaly on 15 February 2010 at Maierato near Vibo Valentia (view www.stumbleupon.com/su/9LP6H7/sorisomail.com/email/42722/ja-viram-desmoronar-uma-montanha.html).

The anatomy of a small landslip

Posted on September 1, 2010 by derasa| Leave a comment

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Arsenic update

Posted on July 1, 2010 by derasa| Leave a comment

Partly because of natural processes and partly due to a shift to avoid pathogens in surface water used for domestic to a massive well-drilling programme much of rural Bangladesh and neighbouring West Bengal in India found itself the epicentre of 'the largest mass poisoning of a population in history', during the 1990s. The agent was soluble arsenic in various forms that reducing conditions in shallow aquifers had released by dissolving its host mineral, iron hydroxide coatings on sand grains. Geological and hydrological attributes of the two hard-hit areas helped develop a model for assessing the risks in other areas. More than a decade on from the world-wide recognition of the tragedy (local geoscientists had their suspicions much earlier) a review of arsenic hazard in both South and Southeast Asia (Fendorf, S. et al. 2010. Spatial and temporal variations of groundwater arsenic in south and south-east Asia. Science, v. 328, p. 1123-1127) is welcome but is not reassuring. The problem now extends to plains of the whole of the Ganges-Brahmaputra-Meghna system, the Red River of Vietnam and the Mekong of Vietnam, Cambodia, Laos and part of Thailand. Almost certainly the Indus and Irrawaddy plains are affected too, though few data are available. The review highlights a haphazard aspect of the distribution of affected wells, both in geographic location and the depth of the tapped aquifer. In the latter case, it was thought that deeper aquifers were less prone to contamination than those in the top 100 m of wells. It turns out that even at depth up to a third of wells exceed WHO recommended levels of arsenic. The positive feature is that many villagers are within walking distance of safe well water. But it is difficult to predict whether or not new wells will be risky, and little is know about safe well's propensity to become contaminated by groundwater flow from elsewhere. Two clear messages are, first to refine methods of testing and assessing hydrogeological conditions, second to move from hand drawn water from individual wells to provision of piper water from high-yielding safe wells.

Ash Wednesday

Posted on May 1, 2010 by derasa| Leave a comment

On 14 March 2010 the Icelandic volcano Eyjafjallajoekull conspired with a major kink in the stratospheric jet stream, itself a possible outcome of 'quiet Sun' conditions, to load the lower atmosphere with its ash cloud. The cloud arrived over most of Europe the following day with outcomes that need no mention here.

Researchers collected samples from the plume over Britain, finding particles mainly of the order of 0.1 mm diameter ranging up to 3 mm. The larger particles account for much of the mass of suspended ash (Sanderson, K. Questions fly over ash-cloud models. Nature, v. 464, p. 1253), but that amounted to only 60 mg m^{-3} in the air over Britain compared with a 'danger level' of 2000 mg m^{-3} declared by the Civil Aviation Authority. That volcanic ash – and presumably dust from sand storms – is hazardous to aircraft is a truism, but little is known about the actual processes involved.

At the speed of modern jet aircraft, mineral or glass dust sandblasts flight deck windscreen, may damage or clog the tubes used to measure airspeed, build up electrostatic charge to interfere with communications and may melt to coat turbine blades (Wikipedia –"volcanic ash"). Two near-catastrophic encounters of Boeing 747 passenger aircraft with ash clouds in the 1980s formed the basis for precautionary halting of all air traffic over most of Europe in mid-April 2010. In both incidents all four engines overheated and cut out, as the ash melted onto turbine blades and prevented them cooling. Fortunately, descent below the ash cloud cooled and shattered the glass coating so that the engines could be restarted. However, unbalancing of the turbines potentially could have caused them to jam irreversibly. Jet engines run at around 1400º C so can potentially melt ash of any composition: at atmospheric pressure the melting temperature of both felsic and basaltic materials is 1000-1200º C. Both the 1980s incidents occurred suddenly in thick ash plumes close to volcanoes, in which ash particles would have been larger than those in the dispersed cloud over Europe in April 2010. Little is known about how melted ash might accumulate in and damage turbines during prolonged flight through very dispersed, ultra-fine-grained ash clouds.

Disruption of aviation schedules is just one continental-scale hazard from Icelandic volcanoes. In the summer of 1783 an eruption of Laki, a fissure volcano further inland, killed 80% of Iceland's sheep, 50% of other livestock and by the end of the year 25% of its human population. The magma was enriched in fluorine and among the emitted gases was hydrogen fluoride that reacted with ash to form metal fluorides that coated vegetation across wide tracts of the island. Ingesting fluorides leads to fluorosis, a crippling disease to which sheep and cows are especially prone. Most of the human victims probably died of starvation. However, archaeologists who exhumed burials from the time of Laki's last devastating eruption found skeletal signs of fluorosis: bony nodules and spiky fibres in joints (see Archaeology and fluorine poisoning in EPN for December 2004). It is a repeat of Laki's toxic ash eruption that Icelanders most fear. During 1783 there were widespread reports from northern Europe of a bluish, acrid smelling haze, probably rich in sulfur dioxide. Contrary to the cooling effect of sulfuric acid aerosols in the upper atmosphere, this acrid fog seems to have warmed the regional summer to possibly the hottest in several centuries. Followed by a bitterly cold winter, Laki's distant effect was devastation of crops, famine and deaths from starvation. It was not restricted to Europe, drought and famine affecting Egypt, India and Japan at the same time, with an estimated global death toll of more than 2 million. This suggests that some of the sulfur dioxide did become trapped in the stratosphere as climatically cooling sulfuric acid droplets that spread over the whole Northern Hemisphere. There are few records of wind patterns from the mid 1780s, yet the filling of Europe's skies with Icelandic dust in 2010 suggests that a similar, wind system prevailed in 1783 – clockwise from Iceland around a large anticyclone centred on western Britain.

When the Eyjafjallajoekull volcano last erupted in 920, 1612, and 1821-1823, the much larger subglacial volcano Katla, 25 km to the east, followed suit. Around 10 600 years ago Katla emitted 6 to 7 km^3 of ash, recognisable in Scotland, Norway and in North Atlantic sediment cores. Many Icelanders regard Katla as potentially their most dangerous volcano.

2010: already a terrible year for disaster.

Posted on March 1, 2010 by derasa| Leave a comment

Early 2010 witnessed horrific scenes on Haiti following a magnitude 7.0 earthquake on the afternoon of 12 January to be followed early in the morning of 26 February by one of the largest ever recorded in Chile (magnitude 8.8). Haiti has suffered fatalities on a scale that match those of the Indian Ocean tsunamis of 26 December 2004, while a huge area of coastal Chile affected by seismic energies more than a hundred times greater had estimated fatalities of over 700, though rising at the time of writing. It is easy to ascribe the relative magnitudes of human tragedy, which are the opposite of the relative seismic magnitudes, entirely to the more advanced infrastructure

of one of South America's most advanced countries compared with that of one of the world's poorest. But that is not the full story. Haiti suffered from a shallow event very close to major population centres whose energy easily reached the surface. The fault responsible involved transverse horizontal movements that sheared through thick soft coastal sediments, which liquefied beneath Port au Prince. That offshore of Chile was much deeper, on a subduction zone and involved vertical movements, so much of its energy was dissipated deep in the crust, yet the area of structural damage along Chile's narrow coastal fringe is much larger than in Haiti.

Sure, Chile has long had stringent regulations for seismic safety of construction and a state of emergency preparedness commensurate with its history of devastating earthquakes, including the largest ever recorded on 26 May 1960 with magnitude 9.5 that released about ~32 times more energy than the recent one. It is a country well-endowed with income from its huge mining operations, well-developed wineries and much else, especially foreign investment. Haiti has nothing but the horrifying reputation of a string of governments. Until the recent tragedy the majority of its people were left to fend for themselves, close to the playgrounds of the super-rich and the offshore hidey holes of 'non-doms'. Yet survivors in both countries face essentially the same physical privations of having to live rough and the lasting horror that no amount of wealth can remove. After experiencing the great Valdivia earthquake of 20 February 1835, also in Chile, Charles Darwin observed,

'An earthquake like this at once destroys the oldest associations; the world, the very emblem of all that is solid, moves beneath our feet like a crust over fluid; one second of time conveys to the mind a strange idea of insecurity, which hours of reflection would never create.'

In both cases lessons may be learned, some socio-economic that are too obvious to repeat here. There is, though, one of that kind that transcends most of the others: the 21st century's first decade has seen a seismic death toll of 640 thousand; a fourfold increase over the previous 20 years fatalities. That is a reflection of increasing drift of especially poor people to cities. If their dwellings are easily smashed they stand little chance. So far, the pledges of aid for reconstruction in Haiti amount to about US$5000 for each damaged structure. For geoscientists, however, what is beginning to emerge from these and the various large earthquakes in Indonesia, Pakistan and China since 2004 is that past seismic history is a clue to future events.

Faults zones behave in a segmented fashion, each with its own crude cyclicity but each somewhat prone to being triggered by events from nearby sectors. Between 1750 to 1770 Haiti was repeatedly devastated when the culprit fault unleashed its pent up stresses. Since then it has been locked in the vicinity of Haiti, with tectonic motions of about 8 mm per year accumulating to the 2 m or so motion undergone by the fault on 12 January. Subduction zones accumulate strain in many sectors distributed along the plate boundary, sometimes locking as seamounts start to descend to 'clog' them. Statistical analysis of historical earthquakes and locating their probable epicentres in relation to fault segments, with estimates of their power that would now be measurable from seismograph data, can at least highlight future risk geographically even if timely predictions remain impossible. Yet will their be action that matches up to the potential hazard? 2000 years ago the destruction of Pompeii and Herculaneum in the Bay of Naples by Vesuvius was recorded in graphic detail of which the excavations presented a gruesome reminder. Yet Naples expands to urbanise the very slopes of Europe's most dangerous natural threat.

See also: Bilham, R. 2010. Lessons from the Haiti earthquake. Nature, v. 463, p. 878-879.

Mid-continent earthquakes: warnings or memories?

Posted on January 1, 2010 by derasa| Leave a comment

Perhaps the most infamously unexpected earthquake was that of 17 December 1811 that shook the historically quiescent middle Mississippi valley with an estimated magnitude of 7 on the Richter scale. The area centred on New Madrid has been resonating with seismic events of lesser magnitude ever since. So too has the area around Charleston, South Carolina on the passive Atlantic margin of the USA, which experienced a magnitude 7 earthquake in 1886. Geophysicists now know to expect major earthquakes at some time in some place along active plate margins, especially subduction zones and boundaries dominated by strike slip motion, although prediction is an art to be learned if indeed it will ever be possible. Yet even small tremors far from plate boundaries within continental parts of plates are a continual worry. The shock of totally unexpected devastation in New Madrid and Charleston makes seismic-risk assessors mark the card of any such events, especially if repeated. Ideally, plate interiors should be rigid and safe. The magnitude 7.9 Sichuan event in May 2008, which caused more than 80 thousand deaths along a fault with no history of activity, reinforced worry. All three examples were situated in areas with old faults, of which most areas of continental crust have plenty, though some are hidden. Somehow tectonic forces had built up and eventually they failed.

Protracted activity might seem to foretell more big 'quakes. However, it now appears that faults in continental interiors behave very differently from those at plate boundaries: aftershocks, even some with magnitude 6, continue for centuries in the first case, but only for a few years or decades at tectonically active margins (Stein, S. & Liu, M. 2009. Long aftershock sequences within continents and implications for earthquake hazard assessment. Nature, v. 462, p. 87-89). The duration of aftershocks in inversely related to the tectonic load sustained by faults. A lesson suggested is that assigning high risk to continental areas with repeated seismicity overestimates the dangers. But does this mean those seismically stable areas in continental interiors pose underestimated risks? The answer is probably 'Yes', if they are near to old faults. That is not to say that the Caledonian and Variscan structures that divide Britain into many small blocks are about to 'go off' at any time. Some do generate small, noticeable tremors such as that beneath Market Weighton in east Yorkshire at 1 am on 27 February 2008 that woke people up to several hundred kilometres away (including me). Market Weighton was an area of reduced subsidence during Jurassic sedimentation, as a result of flanking Variscan faults in the crust beneath. However, if large structures – high-rise buildings, bridges, dams and power stations – are planned, it would be wise to look in detail at local faults. One approach is to map disturbance of superficial sediments that in Britain would show activity over the last 18 to 11 thousand years since ice sheets melted. Another is to check bedrock geology for the last major movements on faults. It may become possible to develop models of seismic cyclicity for all large structures to give realistic assessments of risk in the future.

See also: Parsons, T. 2009. Lasting earthquake legacy. Nature, v. 462, p. 42-43.

Fast-moving rhyolite magma

Posted on November 1, 2009 by derasa| Leave a comment

Highly fractionated, silica-rich magma poses the greatest danger of explosive volcanic eruption, characterised by glowing pyroclastic flows that produce the strange rock ignimbrite. For example, in the Andes, ignimbrites extend for large distances from the calderas that emitted them. Fortunately rhyolite eruptions are rare, but that poses a scientific problem – they have not been as well studied as more common magmatic phenomena. Until May 2008 the latest rhyolite eruption had been in Alaska during 1912. In 2008 the Chilean volcano Chaitén erupted for the first time in 9 thousand years. There was no warning. Andesitic and dacitic volcanoes are restless for months before an eruption, though that is not much comfort as exactly when they 'go off' is still unpredictable. But any warning helps prepare local populations for the worst. A volcanoes precursory rumblings and shakings reflect the slow upward movement of magma. In the case of Chaitén, magma rose at about 1 m s^{-1} that flabbergasted the volcanologists who rushed to study such a rare event (Castro, J.M. & Dingwell, D.B. 2009. Rapid ascent of rhyolitic magma at Chaitén volcano, Chile. Nature, v. 461, p. 780-783). The magma rose 5 km from its source in less than 4 hours. It is generally thought that the more silicic magma is, the more viscous and sluggish, which is certainly the case for rhyolite when it emerges: the melting of impurities in a coal fire produces a very silica-rich melt but such slag certainly does not dribble out of the fire box to pool on the hearth. High viscosity allows an erupting magma to retain gas escaping from solution as pressure drops, which is the source of the catastrophic blasts of massive ignimbrite events. Below the surface the Chaitén magma behaved in an extremely fluid manner, perhaps because it contained so much dissolved gas that it became a fluid froth at quite shallow depth. This unique observation is deeply disturbing for populations living in areas blanketed by ancient ignimbrites, as in the Andes. The very worst terrestrial events imaginable are ignimbrite eruptions that can blast out at such high velocities as to groove the ground and carry over thousands of km^2 in matter of minutes. Without warning, there is no escape.

Wenchuan earthquake (May 2008) analysed

On 12 May 2008 a magnitude 7.90 earthquake killed more than 80 thousand people and left many more injured and homeless in the Wenchuan area of Sichuan province China. In the worst affected areas up to 60% of the population were killed. The catastrophe occurred at the densely populated western boundary of the Sichuan basin with the Tibetan Plateau, and involved surface displacement that propagated rapidly north-eastwards along a 235 km long zone. There was virtually no warning sign and although crossed by major faults, high-magnitude seismicity was a rarity in the area. Several satellites now repeatedly deploy synthetic aperture radar sensing along their ground swath, so that interferometric methods (InSAR) are able to assess ground motions between separate times of overpass, with sub-centimetre precision. Together with direct measurement of motions at GPS ground stations, InSAR allows an unprecedented 'post-mortem' of this dreadful event (Shen, Z-K et al. 2009. Slip maxima at fault junctions and rupturing of barriers during the 2008 Wenchauan earthquake. Nature Geoscience, v. 2, p. 718-724). The structural architecture of the surrounding area is of five fault-bounded blocks that jostled during the event, resulting in profound shifts in the geometry of motion along two parallel faults that ruptured. The event was so sudden and large because what would otherwise have been barriers to propagation of strain failed at the same time. All the strain cascaded through several fault segments. This is not a scenario that could have been easily predicted, the authors judging it to have been a once-in-4000 years concatenation of crustal failure.

Seismic unpredictability is something that seismologists now recognise (Chui, G. 2009. Shaking up earthquake theory. Nature, v. 461, p. 870-872). Active faults turn out not to be 'creatures of habit', and nor can we assume that long-quiet segments are the most likely to fail in future. Ominously, there is a growing body of evidence that great earthquakes are able somehow to trigger others, often far distant. An example is the giant Sumatra-Andaman event of 26 December 2004, tsunamis from which caused a toll of hundreds of thousand lives around the Indian Ocean. It was followed quickly by swarms of small tremors on the San Andreas Fault 8000 km away. Rapid successions of great earthquakes around the world, such as the October 2005 Pakistan earthquake 9 months after that in the Indonesian area, can no longer be regarded as 'bad luck'. Seismic waves are able to weaken far-off segments of active faults.

Detecting natural asbestos hazards

Posted on September 1, 2009 by derasa| Leave a comment

All forms of asbestos (various serpentines and some amphiboles), but especially the blue variety, are carcinogenic because their dusts consist of minute fibres. Most publicity about the hazard that this mineral presents is from cases that stem from its use as an insulator in housing, shipbuilding and other constructions in developed countries. Areas where it has been mined or outcrops naturally are equally risky if wind can pick up asbestos dust under dry conditions. A large proportion of this now banned industrial mineral was mined in South Africa and many cases of asbestosis and mesothelioma in former mining areas have come to light there since the fall of apartheid. The locations of former asbestos mines are well known, and some attempts are being made to bury the waste. The most tragic cases are where the mining companies have either folded or been engulfed by larger transnational corporations; several legal actions for compensation have been dragging through the courts for a decade or more. However, asbestos minerals are common at what were non-commercial levels in many ultramafic rocks. Such rocks occur in ophiolite complexes and Archaean greenstone belts on every continent, and although ultramafics are in a minority as regards rock outcroppings, they are far from rare. In its natural state such land can shed asbestos-rich dust when dry, and urban and communications developments expose the material to wind action.

Asbestos minerals fortunately have distinctive infrared spectra in the short-wave infrared (SWIR), preferentially absorbing photons at around 2.3 micrometres because of their abundance of magnesium-oxygen bonds that such wavelengths cause to vibrate. Remote sensing is therefore a potentially useful means of screening areas of human habitation for asbestos risks (Swayze, G.A. et al. 2009. Mapping potentially asbestos-bearing rocks using imaging spectroscopy. Geology, v. 37, p. 763-766). The authors, from the US geological Survey and the California Department of Conservation, used a sophisticated and costly form of aerial remote sensing that covers the visible and infrared part of the EM spectrum with hundreds of narrow-wavelength bands: so-called hyperspectral imaging. It is possible to highlight areas containing asbestos minerals by matching the measured and mapped surface spectra with laboratory standard spectra of the pure minerals. In the case of the test area in northern California, where suburban expansion is likely to occur or has done already, the geology is known in some detail and the expensive airborne hyperspectral surveys could be focused. The approach gave results sufficiently accurate for preventive measure to be taken; not only for asbestos-rich bare soils, but also the specific kind of vegetation that ultramafic soils encourage.

There is another, far cheaper means of assessing asbestos risks that is not so accurate, but capable of covering very large areas of poorly known geology, especially in less well-off parts of the world. This uses the satellite remote sensing conducted by the US-Japanese ASTER instrument carried on NASA's Terra satellite. ASTER data include 5 narrow wavebands that bracket the 2.3-micrometre part of SWIR, so that it is capable of assessing the distribution of ultramafic rock outcrops using software similar to that for hyperspectral data.

The USGS/California DoC survey could have tested ASTER data to see how effective it would be if more costly airborne data was unaffordable. Sadly the team didn't foresee how a local test of concept might benefit a great many areas elsewhere by using an ASTER scene that would cover their entire study area, be free to USGS scientists and cost only US$85 for anyone working in the Third World.

Nuclear waste: planning blight writ large

The artificial radioactive isotopes generated in nuclear fission reactors have half lives that range from days (^{131}I) to a few million years (^{135}Cs). They pose a thorny problem for disposal since the radiation that they emit collectively is likely to reach 'safe' levels only after tens to hundreds of thousand years, even if they were diluted by leakage into air or water or onto the land surface. They have to be contained, and that demands storage in rock. More over, underground disposal sites must ensure no leakage for geologically significant periods – a great many rare events, such as magnitude 9 earthquakes, large volcanic upheavals and rapid climate changes all become increasing likely the longer the delay time. Apart from Sweden and Finland, no country that uses nuclear energy has a deep disposal site. The focus has been on the temporary measure of reprocessing, and one major facility, that at Sellafield in the UK, is to close down.

In 1987 the US Congress designated only one potential site for investigation as a place for long term water storage in their vast, geologically diverse country: Yucca Mountain in Nevada. The reasoning was that the area is remote and arid, and not so far away from highly secure military sites, so it could be guarded unobtrusively. After 30 years of investigation, Yucca Mountain has been abandoned, with no equally-well researched fallback site (Ewing, R.C. & von Hippel, F.N. 2009. Nuclear waste management in the United States – starting over. Science, v. 325, 151-152). From a geological standpoint, that is not so surprising as Nevada is seismically active; there has been volcanism in the not-so-distant past, it does have groundwater, and that is present in the volcanic ash proposed for storage. Moreover, the water is oxidising and uranium in spent nuclear fuel easily dissolves under those conditions – storage was to be in titanium casks. Clay saturated in anoxic water is a better bet, while the Scandinavian approach seems safer still: galleries and boreholes in dry crystalline basement rock with canisters packed in clay.

Yucca Mountain has been wrangled over for 3 decades, and one component in its abandonment was a change in the proposed 'regulatory period' from 10 thousand to a million years. How compliance might be demonstrated for a period five time longer than our species has existed, and 500 time longer than the length of the Industrial Revolution is something of a problem for bureaucrats, as of course is judging the cost and time for decommissioning obsolescent nuclear plant. If nuclear energy is to play any role in cutting carbon emissions, the volume of nuclear waste is set to rise enormously, but this does not seem to concentrate the regulatory group mind wonderfully.

See also: Wald, M.L. 2009. What now for nuclear waste? Scientific American, v. 301 (August 2009), p. 40-47.

Methane: the dilemma of Lake Kivu

A massive discharge of carbon dioxide from the small but deep Lake Nyos in Cameroon in 1986 killed 1700 local people after a small earthquake and landslide disturbed the bottom water. The lake is stagnant, and carbon dioxide released by exhalation from deep magma chambers beneath it had dissolved under pressure in in deepest levels. Once disturbed, the gas came out of solution to reduce bottom water density so a large volume rose to blurt out gas and deal silent death in the lake's immediate surroundings.

Lake Kivu in the western branch of the East African Rift system borders the Democratic Republic of Congo (DRC) and Rwanda. With an area of 2700 km^2 and a depth of over 400 m it is far larger than Lake Nyos, but similar in having stagnant water below a depth of about 75 m, in which gases are dissolved under pressure. Lake Kivu contains an estimated 256 km^3 of carbon dioxide derived from magmas beneath the Rift and 65 km^3 of methane that probably arises by anoxic bacterial reduction of the CO_2. Cores into Lake Kivu's sedimentary floor indicate massive biological die-offs at roughly millennial intervals, which probably result from magmatic destabilisation of the gas-rich lower waters. Experimental vent pipes have been installed in Lake Nyos and nearby Lake Monoun to remove gas from the deep water (see Taming Lake Nyos, Cameroon and Letting Cameroon's soda-pop lakes go flat in EPN issues for April 2001 and March 2003, respectively), but such a solution for the much larger Lake Kivu would be far less predictable and extremely expensive (Nayar, A. 2009. A lakeful of trouble. Nature, v. 460, p. 321-323). Energy companies based in DRC and Rwanda are now starting to use the 'soda siphon' approach that relieved Cameroon's deadly lakes to capture the methane potential in Lake Kivu. Perhaps that will dampen down the lake's potential for explosive gas surges, but no one knows if it could instead destabilise its uneasy equilibrium. Furthermore, the deep cool water is nutrient rich and may set off planktonic blooms in Lake Kivu's surface waters. DRC is notorious for bandit mining and politics and security even more unstable than the lake that it shares with its tiny neighbour Rwanda. Population density on the lake's shore, always high because of the fisheries and agricultural potential, rose explosively in the aftermath of the Rwandan genocide of 1994.

'Clean' coal and soda pop

Posted on May 1, 2009 by derasa| Leave a comment

An option much touted as a means of having our cake (power stations fired by fossil fuels, especially coal) and eating it (escaping runaway global warming while enjoying a high-energy lifestyle) is extracting carbon dioxide from flue gases, or even the atmosphere itself, and safely disposing of it in long-term storage. Carbon capture and storage (CCS) is not a well-tried technology. Yet some authorities claim it is at the least a means of 'tiding-over' an economy that depends to such a degree on fossil carbon burning as an energy source that it seems unlikely that alternative, carbon-neutral sources can be deployed in time to stave off increasingly awful and plausible climate and thereby social scenarios. There are others who are convinced that CCS is merely an excuse to continue with 'business as usual', and therefore fraught with dangers. Whichever, there are elements of CCS that do concern geoscientists, such as where should it be stored and in what form. Leaving aside some of the geological issues of storage, such as depleted natural petroleum fields or deep aquifers, what happens to CO_2 at depth? There are five possibilities: it remains as a gas; under high pressure it may take on liquid form (CO_2 can exist only as gas or 'dry ice' at atmospheric pressure); it reacts with the rock itself to form some kind of carbonate; under moderate pressure and low temperature it may combine with water to form a gas-hydrate 'ice', as does methane; or it may dissolve in water under high pressure.

The ideal form for long-term storage would be in the form of solid carbonate, but that demands bicarbonate ions combining with calcium, magnesium or perhaps sodium ions. One possibility is through dissolution in highly saline groundwater. The chemical reactions are not complex, but depend on the solubility of carbonates being exceeded because of massive increases in bicarbonate concentrations. However, experiments have had little success. Another means of solid storage is by the combination of atmospheric CO_2 with calcium hydroxide to form calcium carbonate, which is what happens when lime plaster slowly 'cures'. The downside is that the only means of making $Ca(OH)_2$ is by kilning limestone: no free lunch there. To cut a long story short, a view is emerging that CO_2 pumped, in whatever form, into wet rock will end up dissolving in groundwater, to form vast quantities of 'sparkling' water, or 'soda pop' (Gilfillan, S.M.V. and 10 others 2009. Solubility trapping in formation water as dominant CO_2 sink in natural gas fields. Nature, v. 458, p. 614-618). The British, Canadian, US and Chinese team investigated nine natural gas fields in which CO_2 is present as well as petroleum gas, using noble gases and carbon isotopes as tracers of the chemical fate of the natural CO_2 as the reservoir rocks filled with oil and natural gas during maturation. They discovered that the bulk of CO_2 ended up dissolving to form a weakly acidic water under pressure. This is a recipe for filling huge analogies of soda siphons. They did discover that some CO_2 ended up as solid carbonate, but no more than 15%. As those who add Perrier or Volvic to their Scotch should know, carbonated springs are not unknown. Consequently, CCS that uses confined aquifers poses the danger of eventual leakage, whether CO_2 is stored as gas, liquid or in solution. Petroleum geologists often claim that no trap is leak proof, and extensive areas of gas leakage are known over most oil fields; they are an important sign for explorationists, if they can be detected. The other issue is that fans of CCS set much store in re-use of depleted commercial oil and gas fields for sequestration. Such fields have already been depressurised, and nobody knows whether or not they were leaky to gas and water.

See also: Aeschbach-Hertig, W. 2009. Clean coal and sparkling water. Nature, v. 458, p. 583-4.

Geochemistry, mineralogy, petrology and volcanology

Oxygen and the differentiation of magmas

Image via Wikipedia

The bulk of igneous rocks found within and upon the crust formed by one of two fundamental processes of magma differentiation: calc-alkaline and tholeiitic, responsible for island arcs and ultimately continents forming and for generating oceanic crust and flood basalts. The parental material for both is basaltic magma, but the first leads to a decrease in iron in more fractionated magmas, whereas an increase in iron characterised the second. In the first case conditions favour iron entering igneous minerals, whereas in the second they urge crystallising minerals to exclude iron. The most likely explanation is that the calc-alkaline magmas of volcanic arcs devour electrons so that iron exists in the oxidised ferric or Fe^{3+} state and readily forms dense iron oxide minerals whose progressive removal makes the remaining magma less and less rich in iron. More reducing conditions that lack an abundant electron acceptor, primarily oxygen, make the formation of iron oxides less likely, and iron can build up in residual magmas. But how greater oxidation occurs in arc magmas than in those of the oceanic crust has several possible explanations. The most-widely assumed is that it happens because volcanic arcs lie above subduction zones where hydrated and therefore oxidised ocean floor descends into the mantle conferring oxygen to the products of partial melting. Another candidate is the depth at which fractional crystallisation takes place and there are other possibilities. The oxidation state of fundamental magmatic processes can be proxied by determining in rocks produced by fractionation the relative proportions of elements that behave differently in conditions of increased or decreased oxygen. One such pair is insensitive zinc and sensitive iron (Lee, C.-T.A. et al. 2010. The redox state of arc mantle using Zn/Fe systematics. Nature, v. 468, p. 681-685). The surprise is that the parent magmas of both calc-alkaline and tholeiitic fractionation series have identical Zn/Fe ratios, suggesting that both partially melt from mantle with much the same availability of oxygen. The Zn/Fe ratios differ in more evolved igneous rocks from the two series, suggesting that it is in the fractionating magma chambers that the distinctively different oxygenation occurs, not in the zone of mantle melting.

Related Articles

- Geologist's discoveries resolve debate about oxygen in Earth's mantle (scienceblog.com)

The timing of ups and downs of metamorphism

Complex topography of Sri Lanka via Wikipedia

As the temperature and pressure affecting crustal rocks go up and down, as for instance in the thickening of crust when two continents collide and then erosion strips off the cover so that the rocks slowly rise, the rocks undergo progressive changes in their mineral content; in both cases they are metamorphosed. Rising intensity of conditions gives rise to a prograde metamorphic sequence, and when they wane retrograde metamorphism takes place as the elements that combine in minerals react to adjust to new conditions. In some cases it is possible to use the mineral assemblages, specifically the proportions of different elements that are shared between two or more minerals, to chart the changes in temperature and pressure. That reveals the path taken by the rock through temperature- and pressure space, which is effectively a measure of the crustal processes involved and the geothermal conditions under which they acted: a P-T path. Adding the timing to give a sort of movie to all the changes has been hit-or-miss up to now, and based on radiometric ages from igneous rocks formed and emplaced during the metamorphic evolution. Thanks to the finely targeted mass spectrometry that an ion microprobe an achieve, adding the 't' dimension is now possible from the metamorphic rocks themselves (Sajeev, K. et al. 2010. Sensitive high-resolution ion microprobe U-Pb dating of prograde and retrograde ultrahigh-temperature metamorphism exemplified by Sri Lankan granulites. Geology, v. 38, p. 971-974). Minerals based on the element zirconium (Zr), such as zircon and monazite are extremely resistant to the effects of temperature as regards the radioactive and radiogenic elements that they contain, specifically uranium (U) and thorium (Th) and the lead (Pb) isotopes that form when ^{235}U, ^{238}U and ^{232}Th decay. Both these minerals become zoned as successive layers grow during metamorphism, and the ion microprobe can measure the isotopic composition on a later-by-layer and therefore event-by-event basis. The famous granulites (charnockites) of the island of Sri Lanka (Ceylon) reached the peak of their metamorphism (1050°C and 0.9 GPa) at ~570 Ma and began to retrogress about 20 Ma later around the start of the Cambrian. Previously it was not possible to separate metamorphic ages from those when the original rocks formed in the Archaean and early Neoproterozoic. Such high temperatures are very difficult to attain in the crust under normal geothermal conditions unless extra heat is added by large volumes of basaltic magma ponding at the base of the crust during crustal thickening.

Phosphorus, Snowball Earth and origin of metazoans

As any gardener knows, the element phosphorus is an essential plant nutrient or fertiliser, along with potassium and nitrogen plus a host of minor elements that are rarely mentioned as sufficient amounts are generally available in soils. The same necessities for life apply to oceans too, in which amounts vary a great deal from place to place and whose relative proportions have changed through geological time. For the oceans the main source of phosphorus is the continental crust, where the element resides mainly in the mineral apatite ($Ca_5(PO_4)_3(F,Cl,OH)$). This is not an easily dissolved mineral, which is why for agricultural fertiliser it is generally made available in the soluble form of calcium superphosphate ($Ca(H_2PO_4)_2$) that is produced by reaction between apatite and sulfuric acid. Since the land surface was colonised by plants about 450 Ma ago, biological processes made phosphorus more readily available to solution in river water by their break-down of apatite; supply by rivers to the ocean nowadays is of the order of 10^9 kg y^{-1}. Ups and downs of P dissolved in ocean water though geological time would be expected to have influenced its overall biological productivity, controlled by photosynthetic phytoplankton and prokaryotes. Variations of carbon isotopes ($\delta^{13}C$) in organic and carbonate sediments are know to have occurred episodically since Archaean times, suggesting wide fluctuations in both bioproductivity and burial of dead organic matter. However, it has been hard to judge any geochemical reasons underpinning such variations. Since it is now clear that the common iron mineral goethite (FeOOH) 'mops up' many chemical species including phosphate ions by adsorption on its grain surfaces, measuring the P/Fe ratios in marine ironstones containing these minerals is a potential guide to the changing phosphorus concentration in the oceans (Planavsky, N.J. et al. 2010. The evolution of the marine phosphate reservoir. Nature, v. 467, p. 1088-1090).

The US-French-Canadian researchers charted P/Fe ratios in banded iron formations and ironstones precipitated around ocean-floor hydrothermal vents since the Archaean. What emerged were four episodes: from 2900 to 1700 Ma with generally low ratios; the Neoproterozoic from 750 to 635 Ma with much higher ratios; the Phanerozoic from Cambrian to Jurassic with low ratios and post-Cretaceous high ratios. There are several significant gaps in the record of ocean phosphate levels, notable one a billion years long from

750 to 1700 Ma. One factor that probably affected the variation is the way that dissolved silica (SiO_2) drives down the proportion of phosphate adsorbing onto goethite. The rapid evolution and expansion since the Cretaceous of diatoms that secrete silica probably reduced SiO_2 concentration in ocean water as their remains rained down to be buried on the ocean floor; that explains the high P/Fe ratios since about 100 Ma. Earlier Phanerozoic oceans are estimated to have had as much as seven times the present concentration of dissolved SiO_2, thereby explaining the low values of P/Fe in ironstones deposited in the 100-540 Ma range. From 1700 to 3000 Ma the low P/Fe suggests oceanic phosphorus levels equivalent to those from the Jurassic to Cambrian (but perhaps up to 4 times that, depending on the poorly constrained SiO_2 concentrations).

The Neoproterozoic phosphorus 'spike', at a time when dissolved SiO_2 would have been no different from that in earlier times, suggests a massive influx of phosphate to the oceans at that time. It coincides with the two greatest glacial epochs the Earth has experienced: 'Snowball' Earth when glacial ice existed at tropic latitudes. In themselves the massive glaciations offer an explanation for high phosphorus delivery from the continents through glacial erosion and massive run-off during melting. More exciting is that the P/Fe 'spike' occurred at a time of massive perturbations in stable carbon isotopes ascribed to huge explosions of phytoplankton and organic carbon burial, which would have been permitted by high dissolved phosphate in the oceans. A large increase in primary biological productivity, i.e. photosynthesis, would have boosted oxygen levels; a necessity for the emergence of metazoan life forms soon after the end of 'Snowball' Earth conditions. But that begs the question of how glacially ground-up apatite, abundant as it would have been together with vast amounts of other rock debris, came to be dissolved. In today's oceans crystalline apatite is barely soluble. It seems that apatite's solubility decreases as temperature rises, and increases with pH – in alkaline conditions. As well as being cold, Neoproterozoic ocean water around the time of the 'Snowball' Earths was saturated with carbonate ions that helped thick, almost pure limestones to form globally after each glaciation. That spells alkaline conditions favouring phosphate solution. The authors speculate that global geochemical conditions during the Cryogenian Period (850-635 Ma) may have fostered the origin of the metazoans. Maybe, but their data have a billion-year gap immediately before that Period, and genomic molecular clocks suggest that the root metazoans emerged as much as half a billion years earlier.
See also: Filippelli, G.M. 2010. Phosphorus and the gust of fresh air. Nature, v. 467, p.1052-1053.

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The vestige of a beginning

Geoscientists take it for granted that the Earth has a certain age (currently estimated at 4.54 Ga), but it is one divined from indirect evidence, lead isotopes in meteorites and ancient ores of lead derived from uranium. If ever geoscientists are to grasp the nature of the early planet the evidence would be geochemical, yet also second-hand because relics must lie somewhere in the mantle as the crust is constantly being changed. For decades it has been known that the mantle shows geochemical heterogeneity as a result of episodes of partial melting from which the oceanic and continental crust emerged. Even with such an ancient origin it seems intuitively likely that there should be some mantle that has not been interfered with. Now a group of geochemists from the US and Britain have presented evidence for just such ur-mantle (Jackson, M.G et al. 2010. Evidence for the survival of the oldest terrestrial mantle reservoir. Nature, v. 466, p. 853-856). Their data come from Cenozoic lavas collected on Baffin Island and in West Greenland, which gave an earlier clue for having melted from a truly antique source: they contain the highest ratio of helium produced in the Big Bang (3He) to that released by radioactive decay (4He). Repeated melting of the mantle gradually drives off, yet radioactive decay continually replenishes its complement of 4He, so the more reworked a mantle source for lavas is the lower its 3He/ 4He ratio. This notion is backed up by the lead and neodymium isotopes in the Baffin Island and West Greenland lavas and they suggest an age of formation of the mantle source between 4.45-4.55 Ga.

Convection over billions of years ensures a degree of mixing in the mantle, but such is the viscosity of the Earth that there is a good chance that some areas have remained unchanged, the more so if the bulk of magmatism involving deep mantle has been linked to narrow rising plumes. But what emerges from the rest of the geochemistry of these lavas? Provided they have not been contaminated by continental crust through which they have passed, it should be possible using models for the way different elements are contributed to or withheld from magma by mantle minerals to estimate the source mantle's overall composition. The team did this, bearing in mind the uncertainties. Plotted relative to a 'guestimate' of the original bulk Earth based on the geochemistry of chondritic meteorites they sshoww a very good fit for those elements that are likely to be retained by mantle minerals during partial melting: the so-called 'compatible' elements. But the estimated source for the lavas seems to have been depleted in the 'incompatible' elements that are highly likely to enter magma as soon as partial melting starts. This pattern would be expected if the early mantle had undergone some kind of differentiation as a whole, and that would be a consequence of the entire mantle having been molten and then crystallising: some low-density minerals could preferentially have taken in incompatible elements and floated upwards to deplete those elements in the deep mantle. That is compatible with the idea of Moon formation as a result of a collision between the proto-Earth and a Mars-sized planet, which could have released sufficient energy in the form of heat tp completely melt the outermost Earth.

So the data reveal a great deal, especially that this ancient mantle may well have been the parent for all later mantle compositions as the Earth evolved by dominantly igneous processes. But they do not resolve the perennial debate as to whether the Earth accreted from a uniform mix of nebular material of which meteorites are relics, roughly the composition of chondrites, or heterogeneously from different materials that had condensed from incandescent vapour at different nebular temperatures at different times. Moon formation would have mixed up the latter efficiently in a mantle-wide magma ocean, so we may never know. However some of the oldest meteorites contain fragments of condensates that did form at different temperatures.

The vestige of a beginning

Geoscientists take it for granted that the Earth has a certain age (currently estimated at 4.54 Ga), but it is one divined from indirect evidence, lead isotopes in meteorites and ancient ores of lead derived from uranium. If ever geoscientists are to grasp the nature of the early planet the evidence would be geochemical, yet also second-hand because relics must lie somewhere in the mantle as the crust is constantly being changed. For decades it has been known that the mantle shows geochemical heterogeneity as a result of episodes of partial melting from which the oceanic and continental crust emerged. Even with such an ancient origin it seems intuitively likely that there should be some mantle that has not been interfered with. Now a group of geochemists from the US and Britain have presented evidence for just such ur-mantle (Jackson, M.G et al. 2010. Evidence for the survival of the oldest terrestrial mantle reservoir. Nature, v. 466, p. 853-856). Their data come from Cenozoic lavas collected on Baffin Island and in West Greenland, which gave an earlier clue for having melted from a truly antique source: they contain the highest ratio of helium produced in the Big Bang (^{3}He) to that released by radioactive decay (^{4}He). Repeated melting of the mantle gradually drives off, yet radioactive decay continually replenishes its complement of ^{4}He, so the more reworked a mantle source for lavas is the lower its ^{3}He/ ^{4}He ratio. This notion is backed up by the lead and neodymium isotopes in the Baffin Island and West Greenland lavas and they suggest an age of formation of the mantle source between 4.45-4.55 Ga.

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Post-perovskite unveiled

Kei Hirose, the discoverer in 2002 of a ultra high-pressure transformation of mantle mineralogy, has produced a highly readable review of the implications of his work for how the mantle functions (Hirose, K. 2010. The Earth's missing ingredient. Scientific American, v. 302 (June 2010 issue), p. 58-65).

Seismology has long charted the occurrence of step-changes in mantle properties at a several more or less constant depths. Mantle above 410 km provide most of the samples available to geoscientists as inclusions in basalt lavas and is olivine-rich peridotite. From 410-660 km the elements forming olivine take on a different configuration more akin to the mineral spinel; also backed by some direct as well as theoretical/experimental evidence. At 660 km deep seismic properties change dramatically in a major transition zone. Experimental work in the 1970s with mantle chemical compositions at high pressures and temperatures showed that at greater depths the structure of magnesium silicates like olivine, pyroxene and spinel collapses to a denser form with very efficient packing of aoms that is the same as that of a broad group of minerals known as perovskites. That seemed to be the end of the matter. However, continued geophysical investigations and geochemical studies of basalts derived by partial melting of mantle rock teased out complexities in the once assumed simplicity of the mantle. In 1983 analysis of seismic records revealed a further step in physical properties of the deepest mantle (once designated the D layer) that forced a revision to recognise a transition at 2600 km deep, just 300 km above the core-mantle boundary. This now separates the 2000 km thick D' layer from the lowest D" layer in the mantle. Subsequently, chemical heterogeneities in the deep mantle became a major puzzle.

Hirose and his team pushed experimental conditions to match the huge pressures below 2600 km and discovered a yet more efficient, hitherto unknown molecular configuration that arranges magnesium, silicon and oxygen into separate layers: dubbed 'post-perovskite' for want of a already known mineral structure. As well as a small (1.5%) increase in density, the mineralogical change unexpectedly releases rather than consumes heat energy. Such an exothermic process clearly had great implications for how the mantle works. If rock from higher levels finds its way down to and below the D'-D" transition, as might happen if subducted oceanic lithosphere slabs continue ever downwards, it gets an energy 'kick'. Theoretical work revealed that the early Earth would have been too hot for post-perovskite to form. But once it had cooled below a threshold the phase change 'snapped' into existence: that must have significantly changed mantle dynamics. Convective motion in D" that brings material to the D':D" boundary the post-perovskite to perovskite phase change produces a sharp decrease in density and an upward force. So, once D" formed plume formation and overall mantle convection would have increased. That impetus could not have been present before so that early Earth mantle dynamics were more sluggish. That would maintain a hotter core-mantle boundary, thereby slowing cooling of the liquid core and formation of the solid inner core. Moreover, the upper mantle would have been cooler than now, creating the paradox of less surface magmatism on the early Earth. Theoretically, development of D" should have been marked by a 20% increase in heat flow and a paroxysm of tectonics and crust formation. Was that linked with the formation of stable continental crust around 4 Ga, the spurt in continental growth in the late Archaean or some later event (Hirose suggests 2.3 Ga, but no major tectonic shift has that age)?

As well as tectonic implications, the affect of the D" layer on the pace of crystallisation of the solid inner core may have controlled increasing strength and stability of the geomagnetic field. Because only Earth's strong magnetic field protects the surface from life-threatening cosmic rays and the solar wind, in a roundabout way post-perovskite possibly played a role in allowing the origin, evolution and survival of life on our home world. That possibility is pretty much the ultimate link between solid Earth and the biosphere: take note Gaians!
See also: Buffet, B.A. 2010. The enigmatic inner core. Science, v. 328, p. 982-983.

Crustal sagging during major volcanism

Ice sheets during the last glaciation reached more than 2 km in thickness over vast high-latitude areas of the Northern Hemisphere. Even though ice has less than half the density of continental crust, their sheer mass forced the lithosphere down into the asthenosphere by up to several hundred metres. The displaced asthenosphere resulted in a corresponding bulge around the glacial fringe. Continental flood basalts are about three times as dense as ice and reach thicknesses up to 2-3 km, so they would have produced even more subsidence, although set against that is the uplifting effect of reduced density of the crust as a result of magmatic heating. The loading effects of individual volcanoes are well known. Yet surprisingly, there have been few accounts of subsidence caused by CFB loading, and the prevailing view is that plume-related large igneous provinces are preceded by doming and even erosion. Geophysicists at the University of Colorado modelled the effects of plumes and CFB eruption and reverse the general view decisively (Leng, W. & Zhong, S 2010. Surface subsidence caused by mantle plumes and volcanic loading in large igneous provinces. Earth and Planetary Science Letters, v. 291, p. 207-214). They found that phase changes in the rising mantle plume at the 660 km deep discontinuity cause subsidence themselves, so that even before volcanism begins the surface subsides. This is borne out by preservation of basinal sediments beneath some CFB provinces, such as the Siberian and Deccan Traps. Effectively, flood basalts may fill shallow basins that they recreate and maintain due to their loading effect on the crust during successive eruptions. The high elevations of many ancient CFB provinces are a product of later tectonic processes rather than being 'built' by volcanism.

'Microdating' sedimentary sequences

There are few minerals amenable to radiometric dating that are found in all sedimentary rock types. To give ages that are stratigraphically useful they would have had to form authigenically while the sediment itself was accumulating – glauconite in 'greensands' is an example. Calibrated stratigraphy largely depends on dateable igneous minerals found in volcanic rocks interlayered with sediments, the most common being zircon that can be dated precisely using U-Pb methods. The vast bulk of high quality ages of this kind depend on being able to collect sufficient volcanic ash or lava to yield zircon grains. So only volcanic layers thicker than a few centimetres have been used, and they are haphazard in their occurrence in sedimentary sequences. Much thinner ash layers do occur more commonly and uniformly in sequences from arc-related sedimentary basins, and being able to date those would permit much better control over rates of sedimentation and correlation between different sequences. The key is being able to date zircons in thin section (Rasmussen, B. & Fletcher, I.R. 2010. Dating sedimentary rocks using in situ U-Pb geochronology of syneruptive zircon in ash-fall tiffs <1 mm thick. Geology, v. 38, p. 299-302). Rasmussen and Fletcher (Curtin University, Western Australia) applied ion-microprobe methods to polished this sections of diamond drill core through Archaean sediments of the Pilbara craton in Western Australia, specifically to date a thin sediment layer that contains spherules formed by a major asteroid impact. They were able to narrow

its age down to that of a thin ash only 15 mm above the spherules, about 2632+7 Ma. Though with a specialised objective, they demonstrate that semi-continuous stable isotope data in sediments can be calibrated sufficiently precisely to allow global correlations

Geochemical clue to environmental effects of large igneous provinces

Several flood volcanism events seem to link to mass extinctions, and they have been seen as the culprits for global environmental change. Since flood volcanism is outside human experience, geologists have little conception of what they do other than amass up to millions of cubic kilometres of lavas both mafic and silicic. They all probably emitted CO_2 and contributed to global warming, but whether they are able to deliver sulfate and particulate aerosols to the stratosphere to trigger cooling is hard to judge. But it seems there is a proxy for their global influence (Peate, D. 2009. Global dispersal of Pb by large-volume silicic eruptions in the Paraná-Etendeka large igneous province. Geology, v. 37, p. 1071-1074). Lead is potentially a volatile element that would accompany large volcanic gas and dust emissions, and it also bears unique isotopic signatures. Lead isotope proportions in sediments in contemporaneous marine sediments could be matched with those of large igneous provinces (LIPs). Should their signature occur globally, then it would be a fair bet that the products of volcanism did reach cloud-free stratospheric altitudes, there to be mixed globally and to remain aloft for many years. Below the tropopause gas and dust would soon be rained out, so that signatures would remain local.

Dave Peate of the University of Iowa found that the $^{208}Pb/^{204}Pb$ and $^{206}Pb/^{206}Pb$ ratios of 132 Ma sediments from an Ocean Drilling Program core in the mid-Pacific fall in the same field as those of the Paraná-Etendeka large igneous province. The sediments occur just below and within a prominent $\delta^{13}C$ anomaly that geochemists believe to signify a major change in the biosphere, and the site is almost at the antipode of the Paraná-Etendeka large igneous province. Sediments from below the shift in carbon isotopes show lead-isotope ratios that can be explained by derivation from the oceanic crust underlying them, whereas those that witness a profound change in the biosphere overlap with the field of the P-E LIP. Specifically, they match the lead 'signature' of silicic volcanics rather than basalts, and in particular those with low titanium contents. So it seems that in this case basalt floods may not have been implicated in global environmental change, but the much less voluminous but probably far more violent ignimbrite do seem likely culprits. There were more than 20 such events within an interval of less than 2 Ma that emitted >100 km^3 of silicic magma, most exceeding 1000 km^3.

Did mantle chemistry change after the late heavy bombardment?

During the Hadean the Inner Solar System was subject to a high flux of asteroidal debris, culminating in a dramatic increase in the rate of cratering on planetary surfaces between 4.0 and 3.8 Ga known as the late heavy bombardment. It left a subtle mark in tungsten isotopes of the Earth's continental crust that formed during and shortly after the cataclysm (see Tungsten and Archaean heavy bombardment, August 2002 EPN). It has also been suggested that it enriched the mantle in elements, such as those of the platinum group, that have an affinity for metallic iron, a major constituent of many meteorites. The most likely rocks of the Archaean crust to show hints of such enrichment are ultramafic lavas known as komatiites, though to have formed by high degrees of partial melting of plumes rising from deep in the Archaean mantle. Komatiites from their type locality in South Africa and from the Pilbara area of Western Australia do indeed suggest that there was significant effects (Maier, W. D. et al. 2009. Progressive mixing of meteoritic veneer into the early Earth's deep mantle. Nature, v. 460, p. 620-623). The Finnish-Australian-Canadian team found that the older komatiites (3.2-3.4 Ga) contain less platinum-group elements (PGE) than do those from the later Archaean and early Proterozoic (2.0-2.9 Ga). This they ascribe to a surface layer of meteoritic debris gradually being mixed into the mantle by convection. In their discussion they suggest that once the Earth's core formed (almost certainly very soon after the Moon-forming event at 4.45 Ga) it effectively leached all PGE from the lower mantle, and could only have achieved higher concentrations by mixing of later meteoritic debris. Their results suggest that this went on through the Hadean, but reached its acme and then stabilised in the late Archaean once the earlier Archaean alien debris had been churned in.

Planetary, extraterrestrial geology, and meteoritics

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Whizz-bang hypothesis for the Younger Dryas bites the dust

Posted on November 4, 2010 by sdrury777| Leave a comment

Such has been the urge to leap on the impact theory of Earth system change, that virtually every drastic event recorded in the geological timescale has been linked by someone or other to the effects of bombardment by extraterrestrial objects. The most recent concerns the Younger Dryas and the extinction of the mammoths (see Whizz-bang view of Younger Dryas and Impact cause for Younger Dryas draws flak in EPN July 2007 and May 2008). The hypothesis stemmed from reports of an association of tiny magnetic spherules, soot and purported nanodiamonds and fullerenes (carbon molecules bonded into 'geodesic' spheres) with the onset of the Younger Dryas, the roughly coincident disappearance of Clovis tools and the demise of several large North American mammal species, including mammoths. Regular columnist for Science magazine, Richard Kerr, reports that independent searches for all the evidential materials at the sites where they were said to occur have drawn unrelieved blanks (Kerr, R.A. 2010. Mammoth-killer impact flunks out , Science, v. 329, p. 1140-1141). Nonetheless, the core supporters of the hypothesis are clinging to their guns.

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Carbonates on Mars

Posted on September 13, 2010 by linarite| Leave a comment

Ancient valley systems, huge water-carved gorges and sedimentary deposits signify with little room for doubt that early in its history Mars was wet; it must therefore have been warm. A thick CO2-rich atmosphere seems obligatory to give the kind of greenhouse warming that prevented Earth from freezing over when the young Sun was weaker than now. The question is, where did the CO2 go so that the planet became chilled? Gravity on Mars is sufficient to have retained the gas, unlike water vapour that dissociates to hydrogen and oxygen, of which hydrogen easily escapes even a much stronger gravitational field. A consensus is developing that it resides in carbonate minerals. The other likely greenhouse gas is sulfur dioxide, for whose drawdown there is ample evidence in the form of sulfates detected from orbit and by surface rovers. Carbonates have a relatively simple, and unique spectrum of reflected solar radiation, with an absorption feature at a wavelength around 2.3 micrometres. Carbonates have been detected on Mars using orbital hyperspectral imaging, but only in patches. The NASA rovers rely on serendipity for any discovery, yet Spirit did stumble on a large carbonate-rich outcrop identified by its on-board Mössbauer spectrometer (Morris, R.V. and 12 others 2010. Identification of carbonate-rich outcrops on Mars by the Spirit rover. Science, v. 329, p. 421-424). It appears to be a Fe-Mg variety in association with olivines, and carbonate makes up to 34 % of part of the outcrop. The texture is granular, yet the area abounds with evidence for hydrothermal activity in the form of sulfates and silica-rich materials, implying that some kind of circulation system deposited the carbonates. The associated olivine is odd, as that mineral is prone to rapid breakdown to serpentines in the presence of water.

The discovery of carbonate rock does help the CO2 early greenhouse theory and the fate of the warming gas, but aside from the fact the identification has been done at vast distance does it rank with geoscience that can be accomplished on Earth? It is a small piece in the jigsaw of Mars's climatic evolution, but cannot resolve the issue of drawdown of greenhouse gas. The real drama there lay in the finding of abundant signs of water erosion on many scales set against today's surface hyperaridity; evidence for glaciation and subsurface water ice in apparently large volumes. Earth had to have had a thick CO2-rich atmosphere at the same time as that of Mars, but we are still not sure where all that carbon ended up in the early Precambrian, despite limestones and carbon-rich mudstones dating back to 3.4 Ga: as we cannot quantify that aspect of Earth's history, neither can we expect an early answer for Mars. Indeed, what is the benefit set against the cost?

See also: Harvey, P. 2010. Carbonates and Martian climate. Science, v. 329, p. 400-401.

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Wet Moon, dry Moon

Posted on September 13, 2010 by linarite| Leave a comment

Regular readers will remember my remarkable though very reluctant conversion to the notion that there may be water on Mars. My stubborn reaction had been against the background that shrouded the hypothesis with a certain desperation; the need of any future crewed mission to Mars for a water supply and thereby one of hydrogen fuel, plus the determination of the whole Mars-oriented community to justify such a mission by hyping 'xenobiology' on the 'Red Planet'. A similar desperation claoked the search for surface water on the Moon, although one more dominated by the 'Everest' syndrome: since the boot prints and flags appeared, everyone wants to go. The Moons internal water is an entirely different kettle of fish. The hypothesis of the Moon's formation by condensation from an incandescent mass flung into orbit after a planet – planet collision involving the Earth has the corollary that the lunar mantle ought to be bone dry: and so it seemed to be from bulk analyses of rocks brought back by the Apollo missions. In fact, there are a number of possibilities to explain vanishingly small amounts of internal water: the Moon is made of impactor that happened to be dry rather than terrestrial material; Earth and Moon are a mix of both and both Earth and impactor started out dry, but the Earth later received its water from comets; low pressure condensation of the Moon ruled out water entering itss silicate minerals and so on. Then water was found in apatite grains from lunar maria basalts (see Moon rocks turn out to be wetter and stranger in May 2010 issue of EPN). Within a couple of months we are back to the dry-as-an-alco's-throat view (Sharp, Z.D. et al. 2010. The chlorine isotope composition of the Moon and implications for an anhydrous mantle. Science, v. 329, p. 1050-1053). Both terrestrial and meteoritic chlorine isotopes are in remarkably consistent proportions, but lunar rocks show an 25 times greater spread by comparison. To cut a long and complicated discussion short, such a range could only have formed if chlorides of a variety of metals were vaporised from lunar magmas each having its own effect on fractionation of Cl isotopes. In turn, combination of chlorine with metal ions requires virtually no hydrogen ions and therefore vanishingly little water in the moon, otherwise chlorine would have been combined in HCl and not subject to any fractionation when that volatilised on eruption. So that seems settled, then…

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Moon rocks turn out to be wetter and stranger

Posted on May 1, 2010 by derasa| Leave a comment

Since the original analyses of lunar rock samples brought back by the Apollo astronauts is has been widely accepted that they are almost totally anhydrous. Some even contain pristine metallic iron with not a trace of rust after more than 4 billion years. So, therefore, the entire Moon should be bone dry, except for possible rimes of ice preserved in deeply shadowed polar craters. This lack of water is one line of evidence used to support the Moon's origin in a stupendous collision between the early Earth and a smaller companion planet shortly after their accretion. The event may have depleted volatile elements and compounds in the incandescent vaporised rock from which the Moon is believed to have condensed. There are traces of water in glass spherules from lunar dust, but that might have come from the impactors that blasted them from craters. But at this year's Lunar and Planetary Science Conference – the fortieth since the first Apollo landing – evidence for water in lunar minerals was presented (Hand, E. 2010. Old rocks drown dry Moon theory. Nature, v. 464, p. 150-151). The water is in apatite grains that occur as crystals in lunar maria basalts, so must have come from the Moon's mantle through partial melting. Modelling suggests tens of thousand time more water in the lunar interior than believed previously, albeit still much less than in the Earth. Equally surprising is the water's isotopic composition: it has a much greater proportion of deuterium (^2H) relative to hydrogen (^1H) than does water in terrestrial igneous rocks. The giant impact hypothesis suggests that the proportions should be the same in both bodies. One possibility is that a fortuitous comet delivered water to a dried-out hot moon soon after it has coalesced from and orbiting incandescent cloud. Hopefully a full publication will appear soon.

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Posted in Planetary, extraterrestrial geology, and meteoritics

Late formation of Earth's atmosphere

Posted on January 1, 2010 by derasa| Leave a comment

Because the Earth's mantle is rich in volatiles which escape from magmas that reach the surface, it has long been assumed that our planet's atmosphere was self-produced by exhalation. But it turns out that noble gases in such exhalations do not match those in the atmosphere isotopically (Holland, G. et al. 2009. Meteorite Kr in Earth's mantle suggests a late accretionary source for the atmosphere. Science, v. 326, p. 1522-1525). Greg Holland and colleagues from the Universities of Manchester and Houston measured krypton and xenon isotopes in volcanic CO_2 emissions from New Mexico, and found that their proportions matched those in carbonaceous chondrites as does the Kr/Xe ratio. Those in the atmosphere are significantly different, resembling the values in the Sun. Comets may have delivered these gases after the original accretion of the Earth and the catastrophic formation of the Moon.

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Posted in Planetary, extraterrestrial geology, and meteoritics

'Follow the water'

Posted on November 1, 2009 by derasa| Leave a comment

Long, long ago an anonymous Roman wrote, 'The first provision of any civilised society, after a code of law, is a reliable source of clean water'. Personally, I think the phrase 'legalised bureaucracy' in Latin was mistranslated to 'code of law'. Whichever, planetary and life scientists might well like the adage for themselves: the sentiment applies nicely to active planetary tectonics and to the origin and survival of all conceivable life forms. The Earth has plenty of water at the surface and deep in the mantle. Without the second, the main mantle mineral olivine would be too stiff for the mantle to convect. Heat would build up within until magma formed in great abundance and emerged with a dreadful growl, as it did on Venus about 750 million years ago to repave the entire planet. It simply isn't possible to think of answering the questions, 'When did plate tectonics begin and life emerge?' – let alone 'How?' – without first addressing where the Earth's water came from and when our home world become so richly endowed.

In a very practical sense, these are the most important issues in geochemistry. Francis Albarède, of the École normale supérieure de Lyon, President of the European Association for Geochemistry and the first geochemist to deploy a multicollector, inductively coupled, plasma-source mass spectrometer, is a fitting person to review where the subdiscipline stands on them. (An MC-ICPMS is a tool for which many still yearn hopelessly.) His views appeared as a 'Progress' (a rare kind of Nature article) in the 29 October 2009 issue of Nature (Albarède, F. 2009. Volatile accretion history of the terrestrial planets and dynamic implications. Nature, v. 461, p. 1227-1233). The article casts doubt on the long-held views that when the Moon formed after a giant impact on the Earth, both bodies lost huge masses of volatiles, including water, and that Earth's water-rich nature stemmed from repeated bombardment by volatile-rich comets up to about 3800 Ma.

Geochemical data are now available from a comet (Hyakutaki) and it contains twice the amount of deuterium relative to hydrogen that is in terrestrial seawater. The D/H ratio of carbonaceous chondrite meteorites is more Earth-like, and these primitive objects seem a more likely water source than comets. But did cataclysmic formation of the Earth-Moon system dehydrate both bodies and drive off other volatile matter? Planets and smaller bodies formed by gravitational accretion of solids that condensed from the initially hot gas or nebula that dominated the proto-solar system. Experiments show that condensation of the elements occurs in three discrete temperature ranges, separated by ranges in which few elements condense. Above around 1300 K the most refractory elements condensed, including oxides of some elements (Ca, Fe, Mg, Si) that now make silicate minerals, including the dominant mantle mineral olivine. Between 900-1200 K the alkali metals and some of the elements (chalcophile) that readily combine with sulfur emerged in solid form. In the third step from 500-800 K the more volatile chalcophile elements, including lead, and halogens condense, leaving four (Hg, O, N, C) that can take on solid form only below about 300 K. Interestingly, the proportions of volatile elements relative to refractory ones in the Earth, Moon and Martian meteorites are very low compared with those in carbonaceous chondrites. It is likely that volatile elements only accreted to the Inner Planets in small amounts before being swept to the outer reaches by an intense solar wind as the Sun was powering up, i.e. before nebular temperatures had fallen below about 1000 K. From that stems the inescapable conclusion that none of these planets were endowed with much water in their earliest forms.

Proportions of the lead isotopes ^{206}Pb and ^{204}Pb from terrestrial sulfide mineral deposits define a near-perfect linear relationship with the ages of mineralisation, from which an age can be estimated for the time the element lead appeared on Earth. That age is 4400 Ma; about 110 Ma younger than the actual age of the planet, and matches apparent ages derived from I-Xe and Pu-Xe decay schemes; iodine and xenon are volatile elements. This strongly supports the idea that 500-800 K condensates arrived late, and other evidence indicates that they and water ice were delivered by carbonaceous chondrite material falling towards the Sun from far beyond the orbits of the giant planets, once the early solar wind had lessened. That is, the Earth's oceans formed very early in its history, and the mantle gained its water from them once hydrated lithosphere could founder deep into the evolving mantle by subduction. Albarède also summarises fascinating new ideas about the different course followed by Venus and Mars from essentially the same starting point. His 'Progress' is not difficult to read, and by marking the start of a new consensus in planetary evolution is of vital interest to all Earth scientists

Extraterrestrial water is also the subject of a Great Quest by NASA and other space agencies, though sadly an attempt on 9 October to prove that there is ice on the lunar surface, by hurling a US$79 million spacecraft at an obscure polar crater, produced no sensible results. Ironically, a couple of weeks later, three papers appeared in Science that document passive remote sensing evidence that the Moon contains a lot more water than long assumed (the most revealing is: Pieters, C.M. and 28 others 2009. Character and spatial distribution of OH/H_2O on the surface of the Moon seen by M^3 on Chandrayaan-1. Science, v. 326, p. 568-572). The Apollo samples

astonished geologists when they proved to be almost completely anhydrous, any signs of minor hydration being ascribed to contamination after collection. The Moon Mineralogy Mapper (M^3) aboard India's first lunar mission Chandrayaan is a hyperspectral imaging device that operates in the visible to SWIR range of EM wavelengths (0.4 – 3.0 mm). That range includes SWIR wavelengths beyond 2.4 mm where OH^-, water and water ice have large absorption features that are masked in terrestrial remote sensing by the high moisture content of Earth's atmosphere. Pieters et al. attempted to model hydroxyl and water content in the lunar surface, and discovered significant amounts (a few tenths of a percent) in the polar regions. That they got results when the Moon was fully illuminated by the Sun suggests that this is not due to ice hidden from heating in shadows, but to minerals that contain molecularly bound water and hydroxyl ions. That begs the question of how the water got there. One possibility is the late arrival of volatile condensates as above, another that it is due to hydrogen (protons) from the solar wind reducing iron in silicate minerals to metallic iron and combination with the oxygen released. Expect loud hurrahs from devotees of Star Trek and NASA because one prerequisite of civilised society seems to be there on the Moon. But judging from the bureaucracies involved in space, getting the funds to use it will not be easy.

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Posted in Planetary, extraterrestrial geology, and meteoritics

And now; salt domes on Mars

Posted on September 1, 2009 by derasa| Leave a comment

The front cover of the August 2009 issue of Geology could be mistaken for an exaggerated oblique aerial view of part of Iran's Zagros Mountains, well known for their dissected salt domes. It is, however, a simulation of an aerial oblique using digital elevation data from the Valles Marineris area on Mars (Adams et al. 2009. Salt tectonics and collapse of Hebes Chasma, Valles Marineris, Mars. Geology, v. 37, p. 691-694). Hebes Chasma is a roughly oval, steep-sided depression the margins of which show clear signs of some kind of erosion. However, the depression has no outlet, so looks quite bizarre by terrestrial standards: and it is not the only such feature. At its core is a pericline of material that was formerly buried deeper than the flanks of the chasma, which are pretty much horizontal. Unlike the larger, nearby Valles Marineris, Hebes Chasma cannot have formed by erosion of the surface by a huge mass of flowing water, yet 100 thousand cubic kilometres of rock has simply disappeared. Explaining such a gigantic, weird feature taxes the imagination, but the authors do come up with a hypothesis. They reckon that the 10^5 km^3 of material became some kind of thin, briny slurry during an early Martian heating event, which drained downwards into a vast aquifer. For that to happen demands a thick, subsurface layer of dirty ice that melted, and an extremely porous substrate able to channel away the escaping muddy brine. How the pericline formed is not explained, except that it appears in a lab model made of sand, glass beads and ductile silicone polymer, when the silicone drained out through slots in the model's base. There is plenty of evidence that the surroundings of the chasma collapsed spectacularly, and if the pericline formed by the rising of low-density material dominated by ductile salts (or ice) then it is a likely story. But where did the 100 thousand km^3 of gloopy brine go? My guess it followed a secret passage to emerge into the far larger Valles Marineris… Even if there is a crewed mission to Mars, to land anywhere near Valles Marineris would be suicidal, it is so precipitous. So, this is yet another Martian mystery that will linger in a febrile kind of way.

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Is there a giant impact basin beneath the Antarctic ice?

At present there are only two reliable means of surveying variations in the Earth's gravitational field: at the surface using gravimeters and from space, by processing measurements the height of the ocean surface from radar measurements or by accurately measuring the variation in distance between two satellite travelling in tandem over the Earth's surface. The last is used by the Gravity Recovery and Climate Experiment (GRACE) designed by NASA and the German Space Agency. It is the only realistic means of usefully precise gravity surveys over Antarctica. A truly multinational team (von Frese, R.R.B. et al. 2009. GRACE gravity evidence for an impact basin in Wilkes Land, Antarctica. Geochemistry,Geophysics, Geosystems, v. 10, Q02014, doi:10.1029/2008GC002149 – on-line journal) has discovered a prominent positive free-air gravity anomaly over a roughly 500-km diameter subglacial basin in Wilkes Land. A basin filled with low-density ice would normally give a negative gravitational 'signature', so the positive anomaly suggests either unusually dense crustal rocks beneath it, or that the mantle is unusually close to the surface; i.e. the crust is thin. The authors suggest that the central anomaly is surrounded by roughly concentric circular features, and that it is a hitherto unsuspected impact structure, three time larger than the Chicxulub structure (also mapped by gravity data off the Yucatan Peninsula of Mexico) that caused an upward bulge of the mantle. To my eye, the hypothesis only becomes convincing when concentric circles are drawn around the undoubted major anomaly, and the evidence for them is scant compared with the similarly detected structures of Mars and the Moon. What intrigues the authors is the position of the anomaly on a Permian continental reconstruction, It is at the antipode of the Siberian Traps flood basalt province, implicated strongly in the end-Permian mass extinction: the most devastating known. This harks back to speculation that the undoubted Chicxulub structure and caused the mantle to melt beneath its antipode to form the Deccan Traps…

Tectonics

Hard-core continental lithosphere

The oldest and most stable parts of the continents are known as cratons, after the Greek word for strength κράτο (kratos). All the present continents have at least one craton (Africa and South America have 4 each, and Eurasia 6 or 7). Each has remained unaffected by major deformation for a billion years or more, even during continent-to-continent collisions in which they participated. Almost all cratons began to form during the Archaean Eon before 2500 Ma, but most became rigid long after. Several theories have been suggested to account for their durability, one commonly accepted being that somehow the crust 'ripened' so that most of the heat-

producing radioactive isotopes of U, Th and K were moved by igneous and metamorphic processes to the uppermost crust, along with water; most cratons expose fragments of anhydrous granulites of tonalitic composition. These bear evidence of having formed at the base of the continental crust and have been heavily depleted in "granitophile" trace elements. As a result they cannot undergo partial melting under normal geothermal conditions and where they remain at great depth are much cooler than younger, deep crust. The other dominant feature of cratonic lithosphere is a mantle portion that is anomalously thick (sometimes down to 250 km); in some cases there is little if any sign of asthenosphere beneath such 'keels'. Research on rocks brought up from the 'roots' of cratons by the kimberlite magmas famous for their diamonds points to that deep mantle itself having conferred great rigidity and thus longevity (Peslier, A.H. et al. 2010. Olivine water contents in the continental lithosphere and the longevity of cratons. Nature, v. 467, p. 78-81).

The presence of water in minerals that make up igneous and metamorphic rocks enables them to begin melting at lower temperatures than their dry equivalents, and also to behave in a more plastic fashion under stress. Anne Peslier of NASA in Houston and her US and German colleagues analysed the minerals in ultramafic mantle rocks dragged upwards by kimberlites that punched through the Kaapvaal craton in southern Africa long after it formed. The dominant mantle mineral is olivine (50-80%), generally thought of as anhydrous but typically containing a few hundred parts per million by weight. Olivines in the Kaapvaal mantle xenoliths become drier with increasing depth of their formation (determined from their mineralogy in which garnet is stable at the deepest levels). At depths around 150-250 km low water content in olivine makes it and the mantle itself 20 to 3000 times stronger than the asthenosphere, which protects it from the underlying flow associated with tectonic motions.

How such root zone of continents may have formed has been addressed by two papers on seismic structure beneath the best studied craton; that of the Canadian Shield (Yuan, H. & Romanowicz, B. 2010. Lithospheric layering in the North American craton. Nature, v. 466, p. 1063-1068; Miller, M.S. & Eaton, D.W. 2010. Formation of cratonic mantle keels by arc accretion: Evidence from S receiver functions. Geophysical Research Letters, v. 37, doi:10.1029/2010GL044366). In the first, Yuan and Romanowicz of the Berkeley Seismological Laboratory, California use a form of seismic tomography to map anisotropy in the mantle along transects that cross the ancient core of the North American continent. Their results chart the depth of the base of the lithosphere and also define two layers in the lithospheric mantle. The upper layer (down to 150 km) only occurs beneath the Archaean craton, and the top of the asthenosphere ranges from 100-240 km down: at its deepest beneath the craton. The sub-craton mantle they ascribe to chemical depletion of its upper part during early lithospheric evolution, and later addition of the less chemically evolved deeper layer. Miller and Eaton of the Universities of California USA and Calgary Canada used S-wave data from eight seismic stations extending from WSW to ENE over the western cordillera and the Canadian Shield to the Arctic islands of Canada. Their results show a similar variation in dept of the base of the lithosphere and resolve several roughly eastward-dipping boundaries in the sub-craton lithospheric mantle, which they link to Precambrian volcanic arcs preserved in the upper crust above them; i.e. suggesting that the upper layer in the first paper stems from a major episode of arc accretion that built the Canadian Shield.

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Low-angle extensional detachments at ocean ridges

Posted on September 13, 2010 by linarite| Leave a comment

The discovery in the 1970s that some low-angled faults have an extensional or normal sense of displacement stemmed from extensional systems in the continental crust, exemplified by the Basin and Range Province of western North America. Yet the largest extensional systems on Earth are those associated with mid-ocean ridges, and in the 1980s some of those were shown to involve low-angled detachments too. Michael Cheadle and Craig Grimes (University of Wyoming and Mississippi State University, USA) review the latest word on oceanic extensional complexes revealed at the AGO Chapman Conference in May 2010 (Cheadle, M. & Grimes, C. 2010. To fault or not to fault. Nature Geoscience, v. 3, p.454-456). As in continental extension, this kind of deformation at divergent margins may produce core complexes uplifted as a result of tectonic unroofing by low-angled detachments, thereby revealing oceanic mantle lithosphere on the ocean floor. Such peculiarities seem to be absent from fast spreading ridges such as the East Pacific Rise and occur where spreading is slow. They are best developed where spreading is starved of magma injection to produce the classic sheeted-dyke complexes of the middle oceanic crust, and with unusually thick oceanic lithosphere. Yet the ocean floor must spread at these localities, and that is achieved by extensional tectonics that accommodates up to 125 km of spreading with next to no magmatism: 4 Ma-worth of spreading.

For extensional faults to develop into low-angled detachments rocks must be weak, otherwise simple steep, domino-style faults would form. Penetration of seawater down faults weakens oceanic lithosphere through hydration reactions that produce clays and serpentines, which encourage the formation of ductile shear zones. Interestingly, some of the largest hydrothermal systems on the mid-Atlantic Ridge coincide with core complexes, and exude hydrogen – a product of serpentinisation – as well as methane and metal-rich brines.

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Posted in Tectonics

Plate theory moves on

Posted on September 13, 2010 by linarite| Leave a comment

The last 40 to 50 years have seen the theory of plate tectonics supported by more and more empirical evidence from sea-floor magnetism, seismicity, bathymetry and a growing number of other features that relate to Earth's dynamism. Yet the original concepts of rigid plates and their dislocation from one another and the underlying mantle have been undermined to a degree by the wealth of data now available. Increasing resolution of seismic tomography is revealing what is happening in the depths of the mantle on which growing confidence can be placed. Matching these increasingly revealing sources of data has been the computing power to try to blend them all with rheological theory and thereby model the way the world works. The latest of these modelling ventures does seem to move plate theory onto a significantly higher plane (Stadler, G. et al. 2010. The dynamics of plate tectonics and mantle flow: from local to global scales. Science, v. 329, p. 1033-1038). The keys to this step are: increasingly sophisticated software that encompasses the contributory factors, akin to models used by mechanical and hydraulic engineers; faster computing that allows a decrease in the size of the 3-D cells used in assessing all the interactions as realistically as possible, and a great deal of graphic creativity so that we can visualise the results. At its centre is varying rock strength, the principal 'engineering' input derived from seismic tomography, blended with the gravitational and thermal forces that drive Earth's 'engine'.

Stadler et al.'s development divides up the planet into a 3-D mesh whose resolution varies according to the likely complexity of motions within and upon the Earth. For instance there is not much call for detail for what lies below abyssal plains of the ocean floor, so available computing power can be focused on the more intricate parts of the tectonic set-up, especially subduction zones that are both the most spectacular features of the Earth's behaviour and the source of the main force that drives its surface parts – slab pull. Already the approach is producing more questions than answers. For instance, building in the data that show something of convection in the deep mantle makes the model's output for the more shallow-seated and better known processes deviate more than expected from what is observed – less comprehensive and more coarse approaches previously seemed to be match deep and shallow processes quite well. This is a difficult topic to express merely in words, but fortunately the paper has been made freely available at http://users.ices.utexas.edu/~carsten/papers/StadlerGurnisBursteddeEtAl10.pdf

See also: Becker, T. 2010. Fine-scale modelling of global plate tectonics. Science, v. 329, p. 1020-1021.

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Ocean-floor topography-age correlation challenged

Posted on May 1, 2010 by derasa| Leave a comment

One of the elements comprising the canon of plate tectonics is that as plates spread away from constructive margins the depth to the ocean floor increases in direct proportion to the square root of the underling lithosphere's age. This is generally considered to reflect steady passive cooling and increasing density of initially hot lithosphere produced at ridge systems. The resulting slope of the ocean floor is said to result in one of the gravitational forces that sustain plate tectonics – 'ridge slide'. The Pacific Ocean floor is a good test for the hypothesis, but unfortunately does not show a linear depth vs Öage relationship (Adam, C. & Vidal, V. 2010. Mantle flow drives the subsidence of oceanic plates. Science, v. 328, p. 83-85). Instead, the ocean floor flattens out beyond a threshold distance, which has been a source of puzzlement for decades. However, a plot of depth against the square root of distance from the ridge along estimated lines of mantle convective flow is consistently linear. The depth curve seems therefore to reflect past changes in the direction of sea-floor spreading and changes in the deeper mantle convection, thereby linking reality to the original model for continental drift that had mantle convection at its heart. That view was discarded by geophysicists on account of a widespread belief that the asthenosphere was too weak to transmit forces from below to the rigid lithospheric plates.

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Joining the Neoproterozoic dots

Posted on March 1, 2010 by derasa| Leave a comment

Riven by the effects of at least two Wilson cycles of rifting drifting and collision, and then covered by a variety of later sediments, late-Precambrian rocks at high latitudes around today's North Atlantic are nowhere near as coherent as their counterparts in, for instance, Africa. Also they have a long history of field investigation that began long before the unifying theory of plate tectonics, using a parochial rather than a 'joined-up' approach. Consequently there is a vast literature, as witness that of say the Moines or the Dalradian in Scotland, which has strangely acted as a hindrance rather than a boon to synthesisers: not that attempts haven't been made in recent decades. Interestingly, a multi-hemisphere approach to unification, combining Australian and British geologists, seems to have made a

great deal of ground (Cawood, P.A. et al. 2010. Neoproterozoic orogeny along the margin of Rodinia: Valhalla orogen, North Atlantic. Geology, v. 38, p. 99-102).

The Rodinia ('Motherland') supercontinent united all continental lithosphere at the end of the Mesoproterozoic era, existed between 1100 and 750 Ma, then broke into eight drifting continents during the Neoproterozoic. Like the later Pangaea ('all of mother Earth') formed when all these wandering masses finally clanged together again, conditions deep in the interior of Rodinia were probably tectonically and geomorphologically almost static. All the action would have been around its rim, towards which much of global sea-floor spreading ultimately was directed. Far older continental material now juxtaposed across the high-latitude North Atlantic was in just such an exposed position at the edge of the supercontinent; Greenland abutting the present Baltic crystalline mass. Local sea-floor spreading twisted Baltica from this part of Rodinia in a clockwise manner, to leave a large triangular sea in its wake. This Asgard Sea (why not Toblerone?) received debris from uplifted masses of older crust, to fill a deep sedimentary basin ready for deformation should tectonics warrant that. Two such episodes (980-910, 830-710 Ma) created the older Neoproterozoic metamorphic belts which have long drawn geologists to study Greenland, Scotland and Scandinavia in great detail: for British geologists the attraction was the complexity of the Moine Schists in which John Ramsay famously laid the foundations of modern polyphase structural analysis in the late 1950s and 1960s. A noteworthy point is that by comparison with most mountain belts, the Valhalla orogen took an awfully long time to form: around 300 Ma.

An old theory resurrected

Before the wide acceptance of sea-floor spreading and continental drift geoscientists had to seek explanations for the common occurrence of very similar fossils on now widely separated land masses. On the other hand, Alfred Wegener used observations such as the presence of fossilised tongue-like Glossopteris leaves in the Permian sediments of all the southern continents, and similar distributions of reptiles to support his theory. His detractors tried to explain away the fossil evidence by suggesting now-vanished land bridges, 'island hopping', floating seeds, and natural Noah's Arks carrying animals and so on. With the discovery of irrefutable evidence for sea-floor spreading Wegener was vindicated, albeit long after his death, and the views of his detractors became ridiculed and neglected in their turn. But one puzzle remained: the fauna of Madagascar. Beginning about 170 Ma ago, Madagascar along with India parted company with Africa, to the extent that Madagascar is now more than 430 km off the East African coast (India moved much further independently).

Madagascar, of course, is famous for its lemurs but its fauna includes other animals found nowhere else. Another oddity is that late-Mesozoic Malagasy sediments have yielded no evidence for ancestors to these animals, so the fauna could not have evolved from African stock set adrift with the microcontinent. The only explanation then seems to be that the little animal ancestors drifted on vegetation rafts from Africa – note this would be more unlikely for large animals. Yet today's current patterns make any drift toward Madagascar highly unlikely. The puzzle may have been resolved, if one believes computer modelling, by the different surface flow patterns of the Indian Ocean during the Palaeocene (Ali, J.R. & Huber, M. 2010. Mammalian biodiversity on Madagascar controlled by ocean currents. Nature, v. 463, p. 653-656). At that time the drifting island was further south than it is now, and currents would intermittently have flowed from East Africa towards it. As it was driven northwards, so it entered the influence of the westward flowing, South Equatorial Current that now isolates it from its parent continent. The idea of rafting, first developed in 1940 by George Gaylord Simpson, an opponent of anything smacking of continental drift, also seems the only possibility if the arrival of New World monkeys in South America and other oddities are to be explained.

See also: Krause, D.W. 2010. Washed up in Madagascar. Nature, v. 463, p. 613-614.

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Dating subduction

Posted on January 1, 2010 by derasa| Leave a comment

The most distinctive products of the high-pressure, low-temperature metamorphism along subduction zones are stunningly coloured blueschists formed from ocean-floor basalts, their colour deriving from the sodium-rich amphibole glaucophane. Yet the defining mineral for subduction-zone metamorphism is lawsonite, which takes up the calcium from plagioclase feldspar that becomes unstable. Having formed at depths of up to 100 km, blueschists found at the surface had to rise slowly from mantle depths after metamorphism. Consequently, it is nearly impossible to unravel the date of their formation from those of later events. Being basaltic, blueschists also lack the usual elements whose unstable isotopes are commonly used for radiometric dating: potassium, rubidium, uranium and thorium. However, they do contain rare-earth elements, an isotope of one (^{176}Lu) being unstable. Applying the Lu-Hf dating method to lawsonite ties down precisely when basalts achieved the narrow P-T range at which lawsonite forms (Mulcahy, S.R. et al. 2009. Lawsonite Lu-Hf geochronology: A new geochronometer for subduction zone processes. Geology, v. 37, p. 987-990). Sean Mulcahy of the Unigversity of Nevada and colleagues from Washington State chose a sample from the type locality for lawsonite discovered in the late 19th century by Andrew Lawson: the Franciscan blueschists of the Tiburon Peninsula in California. The Franciscan Complex formed during subduction at 145.5 Ma.

Phew, there is a mantle plume under Hawaii after all

Along with constructive and destructive plate boundaries volcanic hotspots within plates and sometimes at plate boundaries epitomise modern Earth science. Assuming that they are fixed points of reference allows the absolute motions of tectonic plates to be worked out, although it seems that some do move around. The evidence for hotspots being fixed or at least moving much more slowly than do plates are the chains of extinct volcanic islands or seamounts that extend away from active volcanic centres in the direction of plate motion. The most debated aspect of hotspots is whether they stem from processes in the upper mantle just beneath the asthenosphere or are the heads of cylindrical plumes of hot mantle that rise from the region next to the outer core. Seismic tomography has been claimed capable of resolving between the two possibilities, but its spatial resolution depends very much on the spacing of seismometers that

provide the data that tomography subjects to highly complex processing. Some have claimed that the resolution of early tomography lends itself to producing artefacts that look like sought-after mantle structures (see Geoscience consensus challenged in EPN of December 2003).

One hotspot that has all the characteristics of a plume head, but which seismic tomography has been unable to detect is the volcanically active Big Island of the Hawaiian chain. The response to that somewhat embarrassing failure has been to deploy 30-odd seismometers on the seabed immediately around Hawaii and then to shift them to a wider spacing further from the island between 2005 to 2007. Together with 10 stations on the islands themselves, the array recorded 2146 S-wave arrivals from 97 earthquakes (Wolfe, C.J. et al. 2009. Mantle shear-wave velocity structure beneath the Hawaiian hot spot. Science, v. 326, p. 1388-1390). The results are reassuring, for the show in detail that indeed there is a vertical zone of low S-wave speeds indicating hotter, less rigid mantle that extends down to at least 1200 km. It is several hundred kilometres across, and is indeed a plume surrounded by a 'tube' of colder more rigid mantle.

See also: Kerr, R.A. 2009. Sea-floor study gives plumes from the deep mantle a boost. Science, v. 326, p. 1330.

Hot tectonics in the Archaean

The first thing that strikes you when looking at a small-scale geological maps of many deformed Archaean terrains – most of them are deformed – is how different they seem compared with those of later aeons. Bulbous granitic plutons separate slim and irregular, sometimes cusp-adorned areas of volcanic and sedimentary rocks. This is classic granite-greenstone terrain. Many geologists who have worked on Archaean rocks find it hard to pin down signs of 'modern' plate tectonics and the typical orogens of continent-continent collision zones, yet non-uniformitarian ideas on Archaean tectonics have become passé in the last 25-30 years. That seems odd, considering that the Earth's internal heat production by radioactive decay must have been higher as less radioactive U, Th and K isotopes would have decayed in the very distant past. Convective mantle flow would have been faster, lithosphere would not have been so thick as now, and plates would have moved more rapidly in order that radioactive heat and that left over from early accretion and the Moon-forming event could escape. Whichever way one looks at such a scenario – plates as big as modern ones or more small plates – there is no escaping that younger, warmer lithosphere would have re-entered the mantle. Geochemistry of Archaean granitic rocks is so different from those of later aeons that their formative processes must have differed too. Quite probably descending basaltic crust would not have dehydrated to produce eclogite under low-T, high-P conditions, and that would prevent steep subduction, so that slab-pull may not have been the driving force for Archaean tectonics.

Two recent papers refresh the idea that the present is not entirely a key to the Earth's Archaean past. One suggests an entirely alien kind of orogenic activity: that of very hot deformation of weak lithosphere (Chardon, D. et al. 2009. Flow of ultra-hot orogens: A view from the Precambrian, clues for the Phanerozoic. Tectonophysics, v. 477, p. 105-108). Dominique Chardon of the Université de Toulouse and colleagues from the Université de Rennes, highlight the dominance in orogens of the Archaean and early Proterozoic of ductile deformation imposed on massive accretion of magma produced by mantle processes, compared with the dominantly brittle style that dominates modern, cold orogens. Accumulated radiometric dating of the main building material of the continents – diorites and grandiorites – indicates that the 1.5 Ga of the Archaean witnessed the formation of not only the earliest continental crust but most (65%) of the rest of it. A summary of an emerging explanation for explosive continent production appeared in the first 2010 issue of Scientific American (Simpson, S. 2009. Violent origins of continents. Scientific American v. 302(1), p. 46-53). This rests on rapidly growing evidence, much unearthed by Andrew Glikson of the Australian National University, for the influence of major impacts that flung debris far and wide and perturbed the mantle's thermal structure on a massive scale (Glikson, A. 2008. Field evidence for Eros-scale asteroids and impact forcing of Precambrian geodynamic episodes, Kaapvaal (south Africa) and Pilbara (Western Australia) cratons. Earth and Planetary Science Letters, v. 267, p. 558-570). Beds of impact-related spherules are turning up throughout Archaean greenstone-belt sequences. There are also megabreccias that could be debris lifted by tsunamis vcaused by impacts in the Archaean oceans. Glikson has demonstrated that the timing of such evidence closely matches that of magmatic outbursts that created continental crust. He has proposed that the thermal effects of the large impacts set in motion or deflected a large number of convective mantle plumes that drove the necessary magmatism.

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Evidence for Hadean continental crust takes a knock

Posted on November 1, 2009 by derasa| Leave a comment

The pre-4 Ga ages recorded by some of the detrital zircons from the 3 Ga Jack Hills sandstones have been used to suggest that continental crust formed from about 4.4 Ga onwards, which implies some kind of recycling process in the tectonics of the early earth to generate and fractionate the necessary silicic magmas. That assumes zircons only form in silicic magmas produced by fractionation in volcanic arcs. The plagiogranites found in small amounts in ophiolites also contain zircons, thereby countering the claim for Hadean continents. More revealing are zircons found in granite magmas that represent the last dregs of melts formed by giant impact (Darling, J. et al. 2009. Impact melt sheet zircons and their implications for the Hadean. Geology, v. 37, p. 927-930). The huge impact-induced mafic to ultramafic melt sheet at Sudbury, Ontario, formed around 1.85 Ga. Zircons extracted from late-stage granites in the body are similar to those with Hadean ages.

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The Great Bend of the Pacific ocean floor

Posted on May 1, 2009 by derasa| Leave a comment

Ocean island chains are trackways of moving lithospheric plates relative to the underlying mantle. Mantle hotspots act in a similar

manner to a candle that would burn a line in a sheet of paper were one to be passed over it. The largest, most coherent and best studied ocean island chain is that of the Hawaiian Islands and the Emperor Seamounts in the NW Pacific. The volcanoes that built the chain range in age continuously from Late Cretaceous (81 Ma) at the northern tip of the Emperor Seamounts where they touch the Kamchatka Peninsula to the present in the Big Island of Hawai'i itself. So far, so good for the hotspot-track hypothesis. But the chain is bent into a WNW segment (Hawaii) and one that trends NNW (Emperor). That might seem to be superb evidence that the direction of West Pacific sea-floor spreading underwent a sudden, 60º change around 47 Ma (the age of the Diakakuji seamount at the apex of the bend). However, measurements in 2001 of palaeomagnetic latitude in sea-floor cores along the chain revealed clear palaeomagnetic evidence that the Hawaiian hot spot has not always been fixed relative to moving lithospheric plates. From Late Cretaceous to Late Eocene times the hotspot seems to have been was shifting southwards relative to the north magnetic pole at a rate comparable with that of sea-floor spreading, and then became stationary to explain the 60° bend in the chain (See American Geophysical Union 2001 Fall Meeting in EPN for January 2002).

Further work has been done since 2001, and a review of the huge oddity that bucks John Tuzo Wilson's 1963 theory of hotspots fixed in space and time is timely (Tarduno, J. et al. 2009. The bent Hawaiian-Emperor hotspot track: inheriting the mantle wind. Science, v. 324, p. 50-53). Data have moved on to suggest that the hotspot is indeed the head of narrow mantle plume originating deep down, perhaps even near the core – mantle boundary (CMB). But could such a massive structure change it's behaviour so that its head would move? Some have suggested the development of a propagating crack in the Pacific lithosphere and then its closure, but no evidence points unerringly that way. After considering a range of possible mechanisms, the authors suggest that the great bend records past changes in mantle flow beneath the West Pacific, so that the plume would itself have bent in the vertical dimension. Seismic tomography has revealed apparently low-angled zones of hot, low-velocity mantle, such as one that may (or may not) connect with the Afar plume beneath the triple junction of the East African Rift, the Red Sea and the Gulf of Aden after rising from the CMB south of Cape Town. They are tantalising results, because the resolution is simply not good enough to be sure. It needs an order of magnitude better tomographic resolution of mantle features to truly make more headway.